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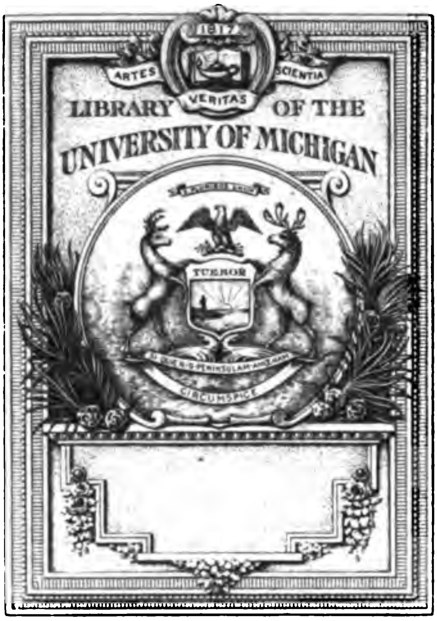
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MEMOIRS OF ART AND ARCHÆOLOGY

Vol. I: No. 1.

A RENAISSANCE LEANING FAÇADE AT GENOA

BY
WILLIAM HENRY GOODYEAR

WITH TEN HALF-TONE ILLUSTRATIONS AND THREE PLATES OF SURVEYS

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OCTOBER, 1902

A RENAISSANCE LEANING FAÇADE AT GENOA.

IN several numbers of the Architectural Record magazine which appeared during 1896-7-8, announcements were made of surveys which have been carried out by the Brooklyn Institute of Arts and Sciences in various mediæval Italian churches and cathedrals. A summary account of the surveys was also published by the Brooklyn Institute in 1896, showing that hitherto unrecognized architectural refinements and subtleties are prevalent in many of these buildings.*

In the summer of 1901, these surveys in Italy were continued with important results. It had hitherto seemed probable that the mediæval architectural refinements, which had been discovered, had generally become extinct before the Renaissance, and the manner and cause of this mysterious extinction were one of the puzzling features of this study. In 1901, however, several instances of Renaissance survivals of the phenomena were observed. One of these is the case of a constructive leaning façade in the Renaissance church of S. Ambrogio at Genoa.

On the day of sailing from Genoa for New York in 1895 (after six months surveying work in Italy), a forward inclination of this façade was noticed, which appeared to be constructive. Among the various indications of constructive intention those at the southwest corner of the church are most easily described, because the side view is concealed on the southeast by an adjoining monastery.

At the southwest angle, as seen from the side (Fig. 1), the base courses, plinth, and mouldings were noted as level. On the other hand, the pilaster had a slight forward tilt, which appeared to be produced by masonry cutting. The front lower angle of each pilaster block appeared to be slightly obtuse, and the rear angle of each block appeared to be slightly acute (Fig. 1).

Of course, if the obvious lean (Fig. 3) had been due to settlement, then the base mouldings would have dipped downward toward the front.

There was no time, in 1895, to test these observations by the level. They were consequently not mentioned in an article which was published on constructive leaning façades in 1897; Architectural Record, Vol. VII., No. 3, "The Problem of the Leaning Tower of Pisa."

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*Illustrated catalogue of the Goodyear Collection of Photographs of Italian Architecture and of the Survey of Italian Mediæval Buildings. For a complete list of publications by the author of this paper on the subject of the Brooklyn Institute Surveys and on architectural refinements, see the third page of the cover.

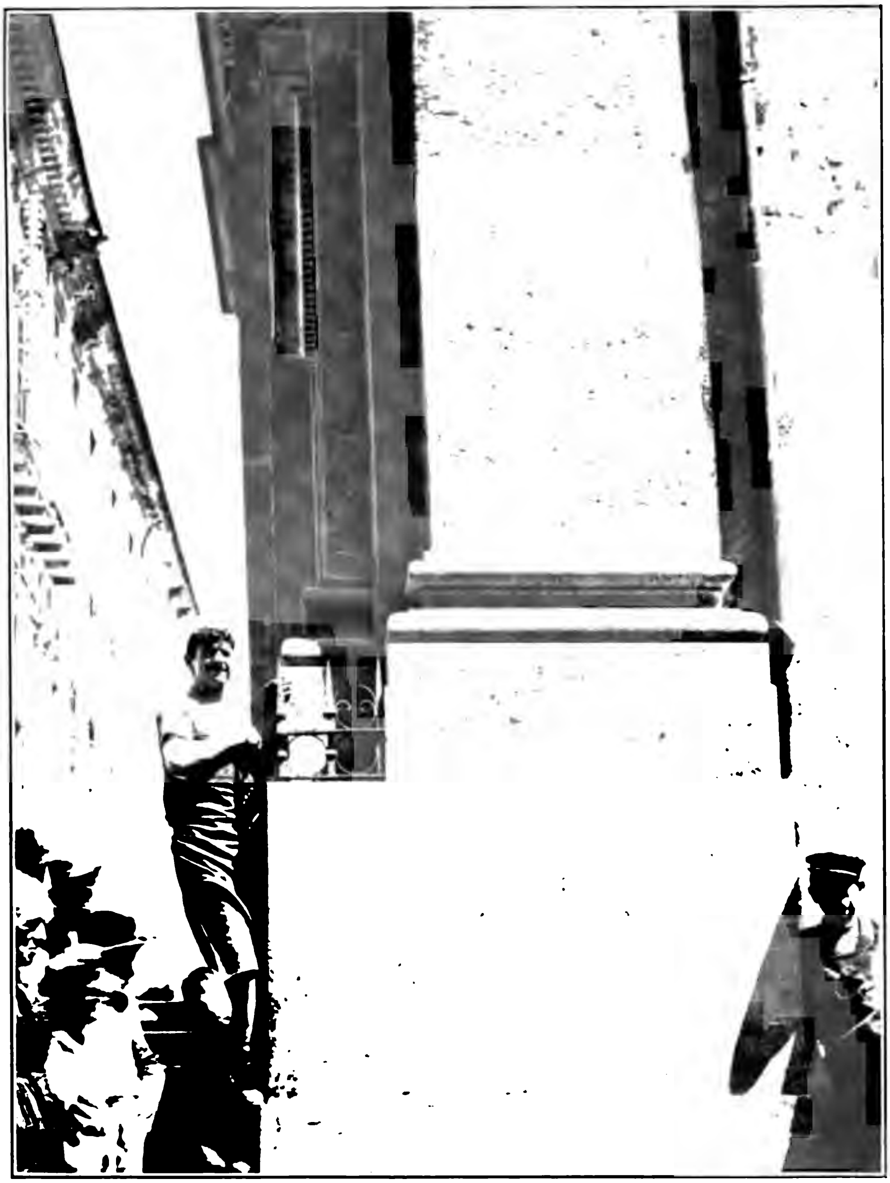

FIG. 1. THE LEANING FAÇADE OF S. AMBROGIO, GENOA.

Detail showing the oblique cutting of the angle pilaster. Photograph of the Brooklyn Institute Survey, 1901.

Genoa was revisited a year ago, especially for the purpose of testing these observations. The fact of the lean proved to be too obvious for dispute. The only question to be settled was whether it was constructive. Having settled this point by the use of the level and by careful examination of the masonry, it seemed to be advisable to have the facts corroborated by an Italian expert.

The expert selected was the architect now in charge of the church, Signor Luigi De Andreis, who has high standing in Genoa as an engineering architect. His certificate follows here:

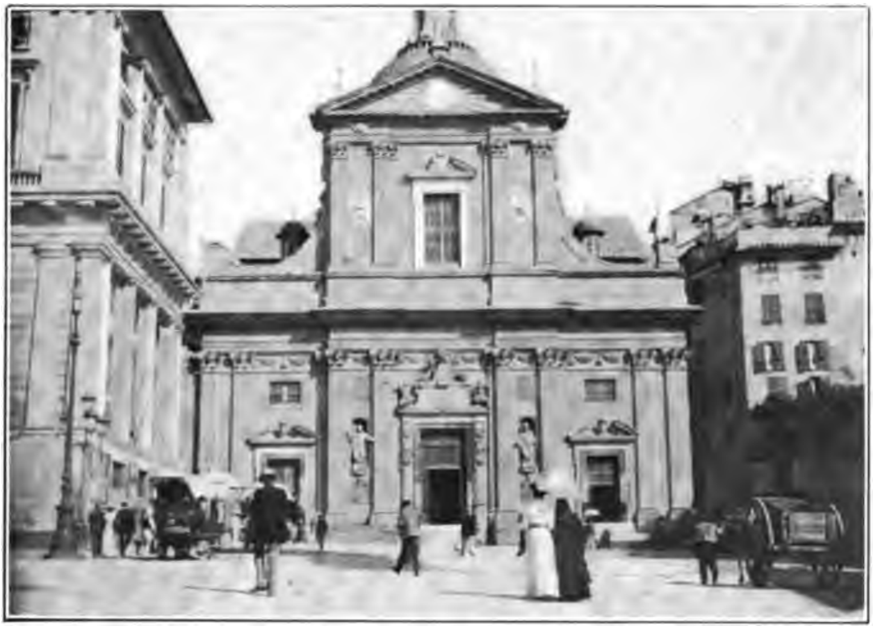

FIG. 2. S. AMBROGIO, GENOA.
General view of the Façade. Photograph of the Brooklyn Institute Survey, 1901.

Genoa, Piazza Invrea, 8. July 23, 1901.

Honored Sir: In accordance with your wish I now offer you some notes respecting the façade of the church of S. Ambrogio. This façade was constructed only in part, that is to say, in its lower half, near the end of the 16th century. Recently, in 1891, 1892, 1893, this existing portion was repaired, and the façade was finished by the addition of the upper portion.

While this work was going on the fact was ascertained that the lower part of the façade had a vertical inclination or lean of about twenty centimetres in a height of about fifteen metres.

The upper part was naturally built without any inclination. We cannot attribute the inclination of the lower part to the interior thrust of the arches or to any other cause of injury, since in that case there would have been partial distortions [of the masonry].

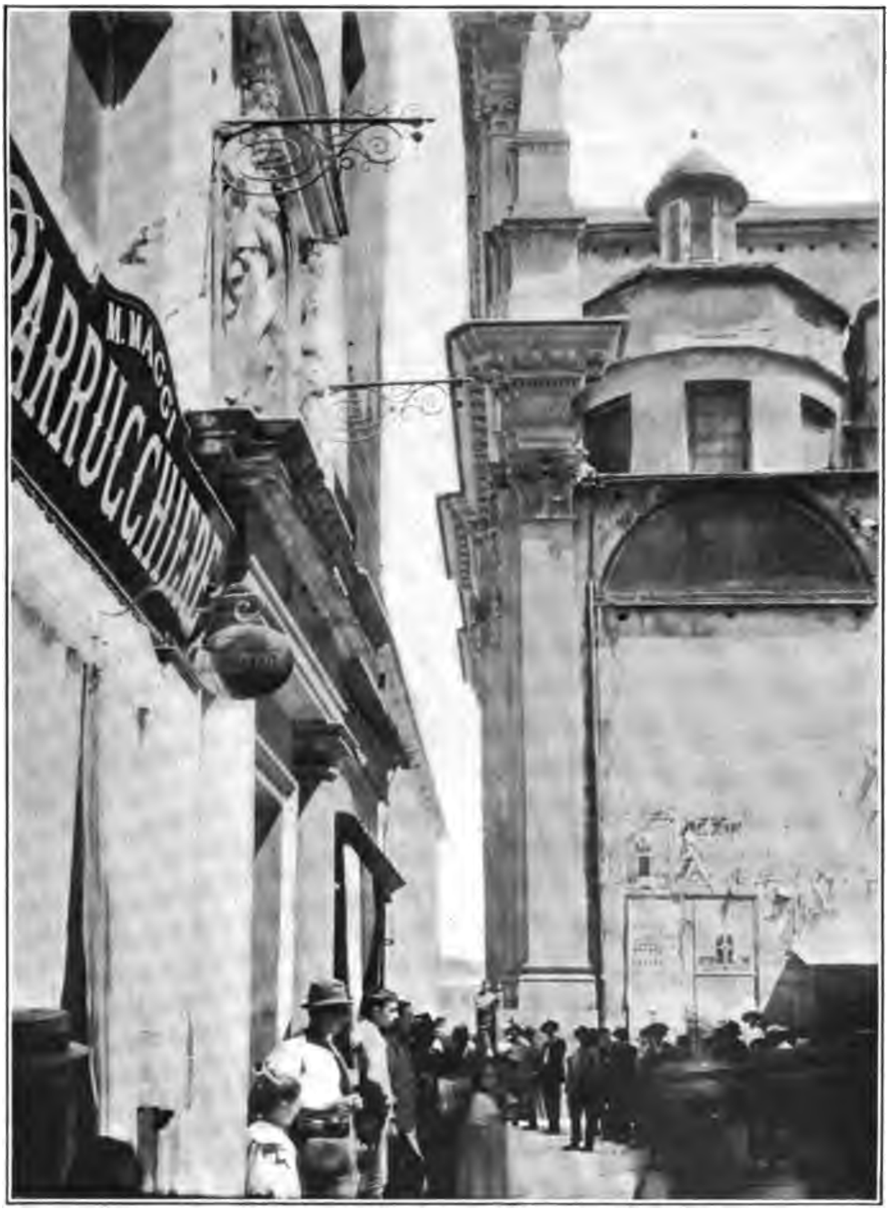

FIG. 3. THE LEANING FAÇADE OF S. AMBROGIO, GENOA.

The overhang is about 8 inches in 56 feet. Photograph of the Brooklyn Institute Survey, 1901.

On the contrary the given inclination is in a certain measure constant throughout the façade, while its decorations* are horizontal and not inclined in the direction of the lean. Hence it must be supposed that the façade was originally built with the aforesaid inclination.

Luigi De Andreis,
Architect directing the work on the façade.

The original Italian certificate is published in the Journal of the Archæological Institute of America, Vol. VI., No. 2, New Series. The facts being thus established their bearings have to be considered.

First, as to the purpose of this device, it can hardly have had any other than that of evading the effects of foreshortening. The same purpose which leads us, in hanging pictures, to tip them forward from the wall, would explain the wish of the architect to give the façade a slight forward lean. The same thing was done at an earlier date (15th century), with the pinnacles and statues on the top of St. Mark's façade at Venice, as attested by Commendatore Pietro Saccardo, who was in 1901 the engineering architect in charge of that church, and who observed this fact some years ago, as related in a later part of this paper.

The now vacant pedestal, 55 feet high, once belonging to a colossal statue of the Roman Marcus Vipsanius Agrippa, which stands before the Propylæa at Athens, on the left as one ascends the hill, has a very perceptible constructive forward tilt. The purpose of such an arrangement, especially in view of the approach from below, is self-evident. Vasari tells us, in his life of Michael Angelo, that this artist prepared the wall of the Sistine Chapel, on which he painted the Last Judgment, by giving it an additional coating, with a forward slope, amounting to one foot at the top. Vasari adds that this was done to prevent the settlement of dust, but it seems more likely that it was done to avoid foreshortening.

These various well-attested instances would enable us to understand the given device in the case of this Renaissance façade, and the instance of the Sistine Chapel offers a connecting link, as regards dates, with earlier cases.

This brings us to an interesting point connected with the date of the church and with its style. This date is comparatively recent, about 1590. And yet, although the architect was a Jesuit Father, the knowledge of his delicate device has not been cherished by the priests in charge of the church, and this knowledge has wholly disappeared in Genoa.

It is interesting to discover a certified case of a leaning façade of which the traditional memory has disappeared within the limits of modern history; since the year 1600, since the invention of printing and since the rise of literary record regarding architecture. Such an instance makes it easier to understand the disappearance of such traditions before printing, and before the literary record of architectural science was practiced.

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*Meaning the base mouldings.

Another phase of this matter is that of style. S. Ambrogio, at Genoa, stands on the border of the late Renaissance style. The great rarity of such cases within the limits of the Renaissance period is undoubted. It is doubtful if there is another Renaissance leaning façade in Italy. This is, so far, the only country in which our search for such phenomena has been systematic or widely extended, and consequently the only country of which I can speak

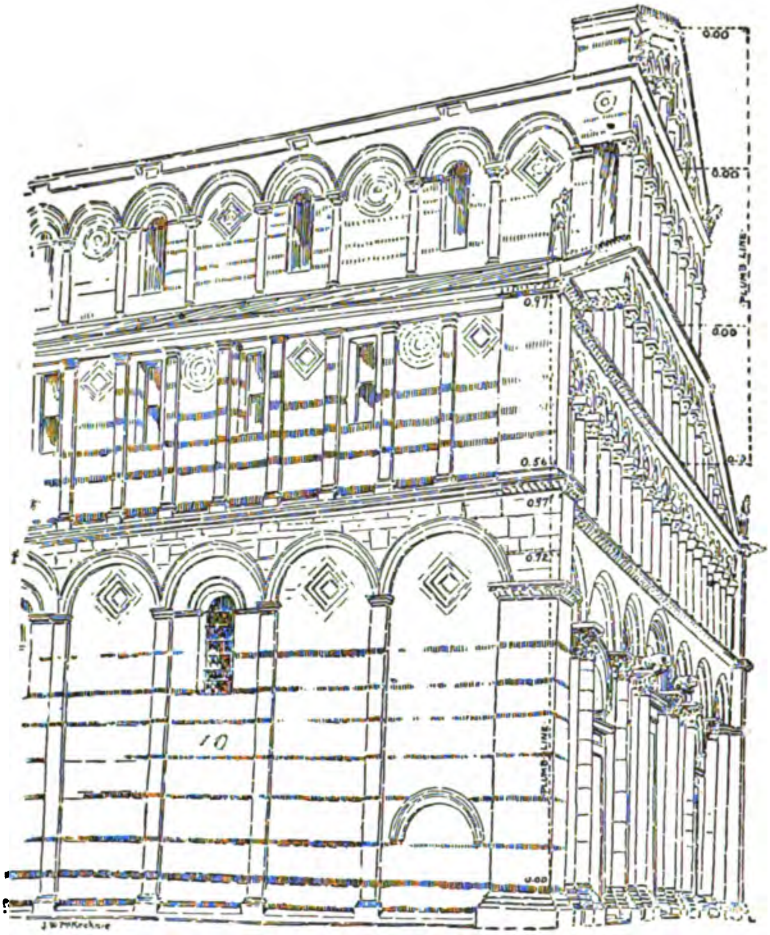

FIG. 4. THE LEANING FAÇADE OF PISA.

Republished from the Architectural Record, Vol. VII., No. 3. Measurements in foot decimals are entered on the drawing. The entire amount of the inclination is about 17 inches, with a return to the perpendicular in the three upper galleries. Tracing from a Brooklyn Institute photograph. See also Figs. 5 and 6.

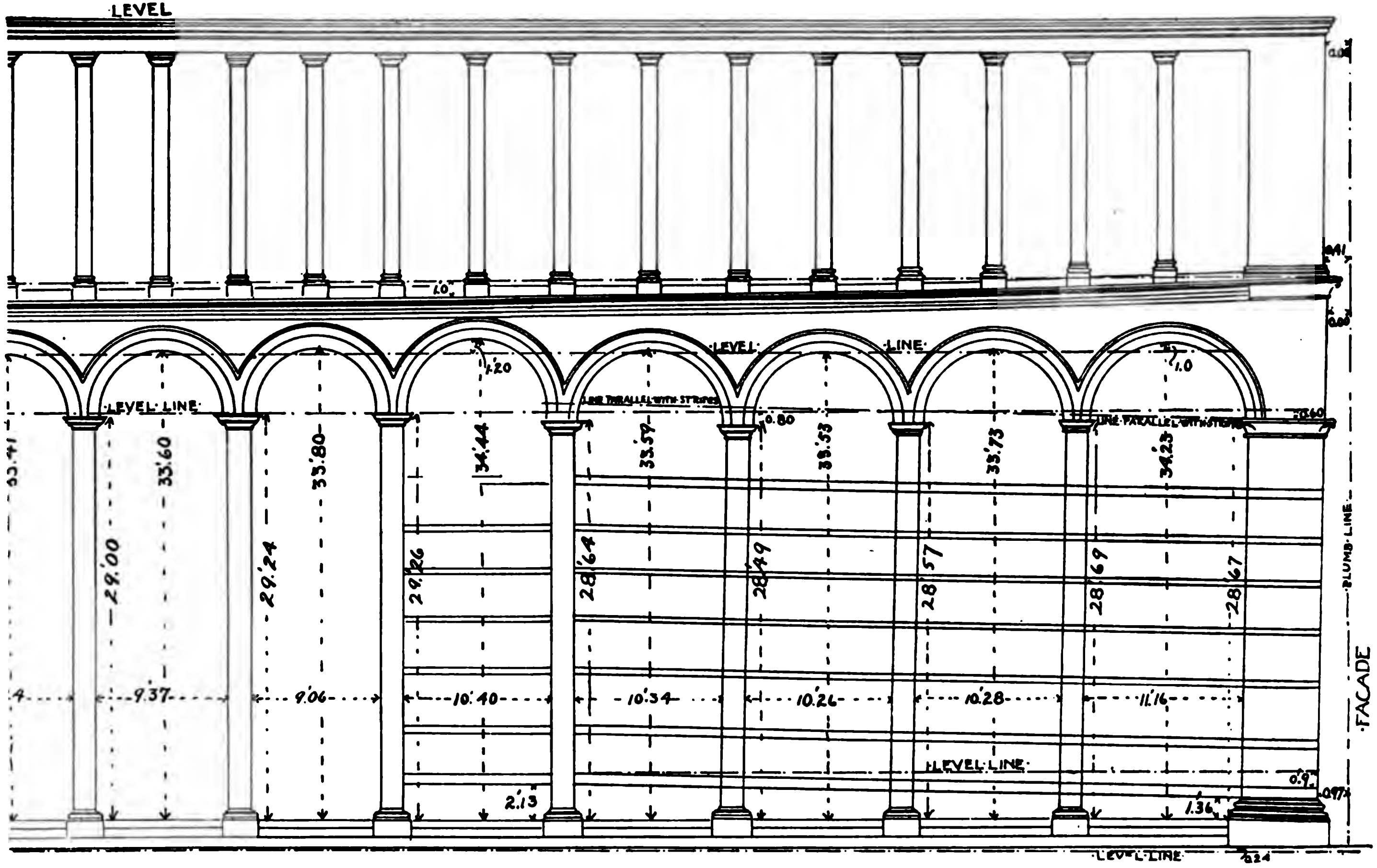

FIG. 5. SURVEY OF THE NORTH CATHEDRAL WALL AT PISA, NEAR THE FAÇADE.

The measurements and levels show that the bend of the masonry stripes and the connected inclination of the façade are constructive. Measurements in foot decimals. Brooklyn Institute Survey of 1895. Republished from the Architectural Record, Vol. VII., No. 3.

at present with much security. It may, however, be considered probable that this is the only Renaissance instance in Europe.

In the articles which have been published on the mediæval phenomena it has been pointed out that they dwindle and become minimized in amount in the later Middle Ages; i. e., that they did not disappear suddenly. We are led back to this fact by the discovery of an apparently isolated case of a Renaissance leaning façade, because it is always easier to understand a gradual fading away of a traditional practice than it is to conceive of its sudden disappearance.

Leaning façades were certainly not numerous in Italy at any period. Careful search in a very large number of Italian towns, and including all of the generally quoted and better known churches of Italy, has revealed the following instances:

That of the Pisa Cathedral is the most remarkable (Figs. 4, 5, 6) on account of the abundance of evidence in the masonry cutting for the constructive intention. It was originally announced by me as a constructive leaning façade in 1874* on the strength of observations made in 1870. The evidence was strengthened to the point of absolute certainty by the surveys of 1895.† In 1901 this evidence of the published surveys was presented to Signor Annibale Messerini, the engineering architect now in charge of this cathedral. He examined the building with me, and his certificate is appended here.

The original Italian certificate is published in the Journal of the Archæological Institute of America, Vol. VI., No. 2, New Series. This certificate also covers other announcements concerning the Pisa Cathedral, which are found in the various articles which were published in 1896-7-8, in the Architectural Record:

Pisa, August 9, 1901.

Honored Sir: I have examined your measurements of the monuments of Pisa and am able to say that the proofs are complete for the following facts:

1st.—That the façade of the Pisa Cathedral was intentionally inclined in the original construction.

2d.—That all the curves of this building, both the horizontal and the vertical, were intentionally made in the original construction.

3d.—That the oblique lines of the interior galleries were built as they now appear.

4th.—That the main exterior cornice is oblique by construction.

With assurance of high regard,

Annibale Messerini, Engineer.

[Architect in charge of the Pisa Cathedral.]

The whole overhang of the Pisa façade is 17 inches, but it does not project beyond the forward edges of the great plinth blocks at its angles.

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*"Scribner's Magazine," Vol. VIII., No. 4, 1874.

†Architectural Record, Vol. VII., No. 3, "The Problem of the Leaning Tower of Pisa," 1898.

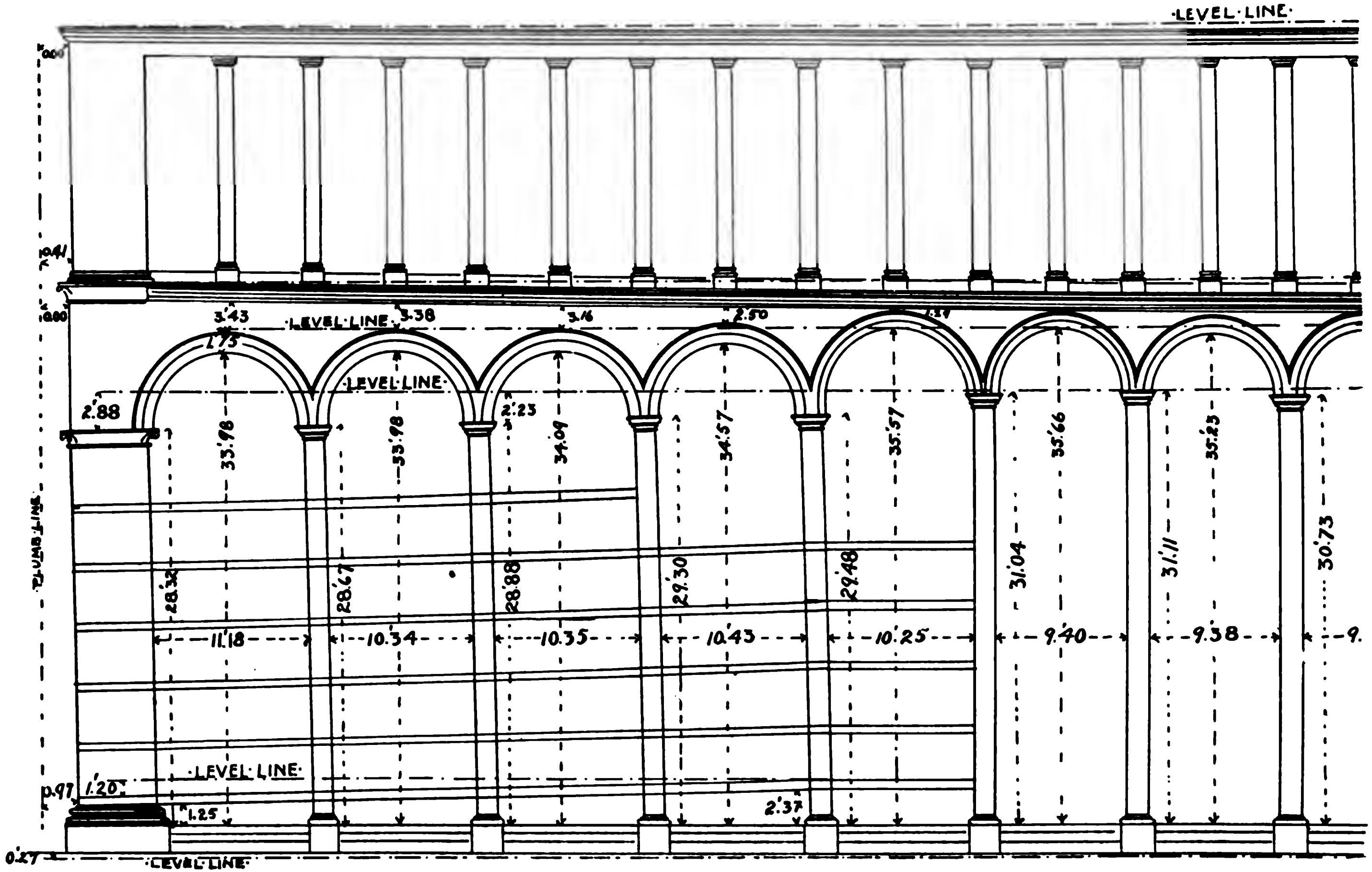

FIG. 6. SURVEY OF THE SOUTH CATHEDRAL WALL AT PISA, NEAR THE FAÇADE.

The measurements and levels show that the bend of the masonry stripes and the connected inclination of the façade are constructive. Measurements in foot decimals. Brooklyn Institute Survey of 1895. Republished from the Architectural Record, Vol. VII., No. 3.

It straightens back to the perpendicular in the three upper stories. The third story (second gallery) only tips forward a tenth of a foot, and the two upper stories are perpendicular. This peculiarity of a return bend to the perpendicular is shared by the leaning façades of S. Michele at Pavia (Figs. 7 and 8) and of S. Ambrogio at Milan (Figs. 9 and 10), both of which are undoubtedly constructive. The return curve of S. Ambrogio is shown by Fig. 9, but the return curve of S. Michele (Fig. 8) is mainly above the limits of the photograph. It may be noticed on the left of the picture at the top. An enlargement of the negative up to 25″ × 35″, now in the Brooklyn Institute Museum, shows the beginning of the curve quite clearly.

As regards the constructive facts in S. Michele at Pavia, a photograph taken in 1901 is very effective (Fig. 7). It shows an upward tilting of the base courses. These mouldings would dip downward, if the façade had settled.

In Fig. 9, the return curve of S. Ambrogio at Milan is shown from the inside of the portico (second story) as being against thrust. As the return curve is constructive, of course the lean must be the same (Fig. 10). This lower façade thrusts against court arcades of the same date and is supported by them. The capitals of the piers have been observed as horizontal, although the picture does not show this. If the façade had settled, the tops of the capitals would dip downward. There is also conclusive evidence in the masonry cutting so far unpublished.

Notre Dame at Paris offers another instance of a front which leans out below and then straightens to the perpendicular (by an offhand change of direction, not by a curve). The inclination does not extend above the first story, and is roughly estimated to be about nine inches. Those who examine this façade in Paris should be careful to notice that the buttress masonry at the lower part of the northwest angle is a modern repair, and here the lean has been obliterated.

The facts regarding Notre Dame were hastily observed during the Paris Exposition of 1900. They were published in the Journal of the Archæological Institute of America, Vol. V., No. 1., New Series, 1901.

The leaning façade of the Ferrara Cathedral has already been noticed and illustrated in the Architectural Record.* This is the one important mediæval instance, so far observed, which shows a continuous forward lean (Fig. 11), as distinct from a return bend. There are no partings of the masonry on the sides, such as would have occurred if the foundations of the building had yielded. The amount of this lean appears to be about 22 inches in about 96 feet.

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*Vol. VI., No. 1, p. 8; Vol. VII., No. 3, p. 287.

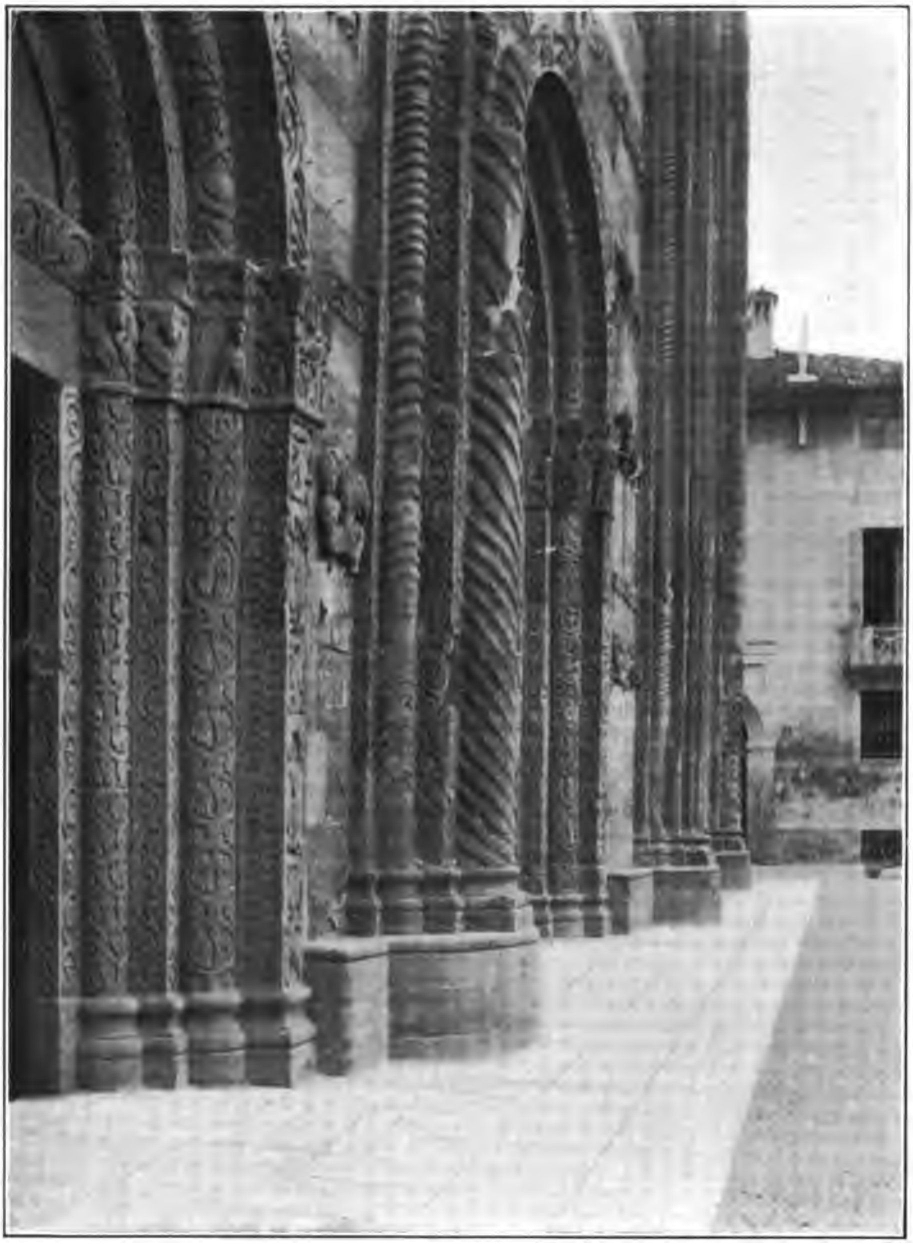

FIG. 7. THE LEANING FAÇADE OF S. MICHELE, PAVIA.

Detail showing the upward tilt of the plinth mouldings. Photograph of the Brooklyn Institute Survey, 1901.

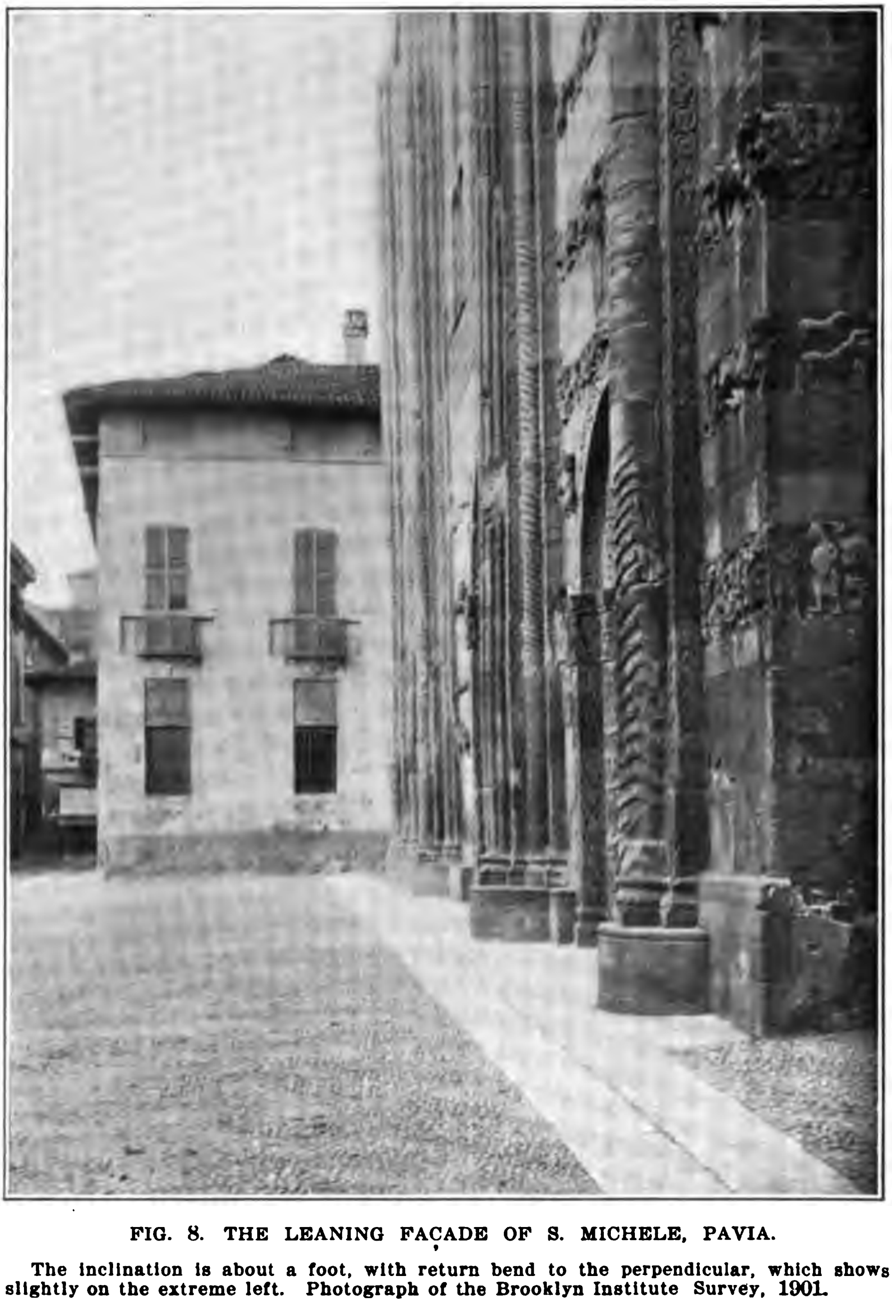

FIG. 8. THE LEANING FAÇADE OF S. MICHELE, PAVIA.

The inclination is about a foot, with return bend to the perpendicular, which shows slightly on the extreme left. Photograph of the Brooklyn Institute Survey, 1901.

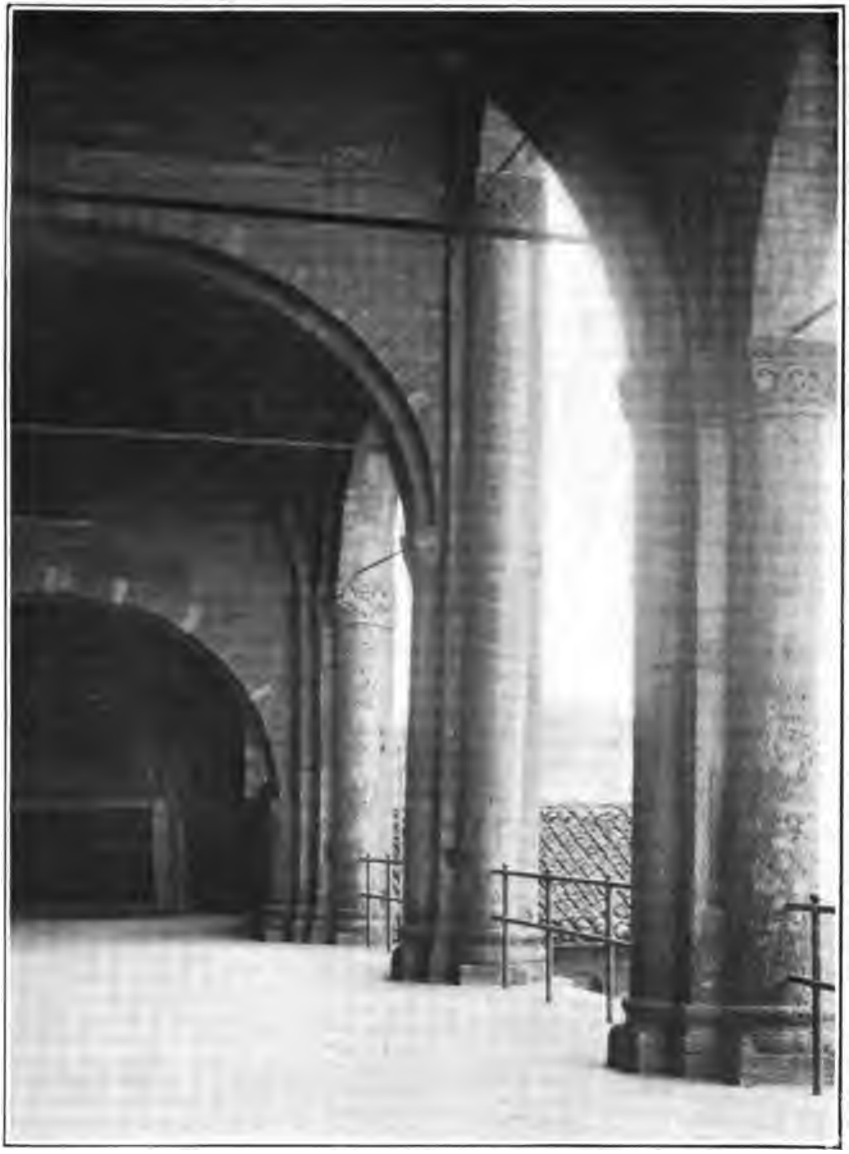

FIG. 9. RETURN CURVE OF THE LEANING FAÇADE OF S. AMBROGIO, MILAN.

Taken inside the portico of the second story. Photograph of the Brooklyn Institute Survey, 1901.

Thus we are able to quote, so far, four important mediæval instances, in Italy, of which three are certainly impregnable, and I have, personally, no doubt about Ferrara.

On the other hand, there are three leaning façades in Italy which must be considered as probably accidental. In the Cathedral of Volterra the south wall has bulged out so far, that it had to be supported by a building which was erected against it. This fact casts suspicion on the constructive intention of the leaning façade at Volterra, although there is, on the face of things, no reason why a building which was constructed with such a refinement should not also have met with an accidental mishap. There is a concave curve in plan in one of the upper faces of the Parthenon, which has been attributed by Penrose to the explosion which ruined the building. This has never been held by Penrose, or by others, to cast doubt on the existence of constructive curves in the Parthenon.

Two other doubtful cases are those of S. Pierino at Pisa and of S. Simone Juda at Lucca. The façade of the Madonna dell'Orto at Venice is very probably a good constructive instance. There is nothing to discredit it, excepting the fact of its being in Venice, where the foundations of buildings are supposed, without very good reason, to be peculiarly unstable. This façade curves back to the perpendicular, and this alone seems to establish constructive purpose. The observations of this church (in 1895) were rather hurried, and no plumbs were taken, so that for the present it must be considered as an undetermined case.

In 1901 I re-examined the small church of S. Giovanni e Paolo at Bologna, which is mentioned in the Architectural Record, Vol. VII., No. 3, p. 286, and determined that the lean was too slight for quotation. A hasty observation of S. Agostino at Cremona, made in 1895, has been mentioned on the same page of the Architectural Record. This church has not been revisited.

Some additional observations of 1901 for constructive leaning faces, are important, although they do not concern façades.

In the church of S. Francesco at Arezzo, where the choir is recessed, the walls on each side of the choir, fronting the nave, have a strong forward constructive slope. These walls had fresco decoration. A close analogy with the wall of the Sistine Chapel, above quoted, may be suggested for this instance.

The exterior of the choir of the Cathedral of Palermo leans out very remarkably at the cornice, apparently in order to evade the foreshortening of the fine decoration which is there applied. The choir of the Pisa Cathedral leans out as much as the façade, and also straightens to the perpendicular in the upper story. The upper part of the façade of S. Frediano at Lucca curves forward almost as much as an Egyptian temple cornice. It has mosaic deco-

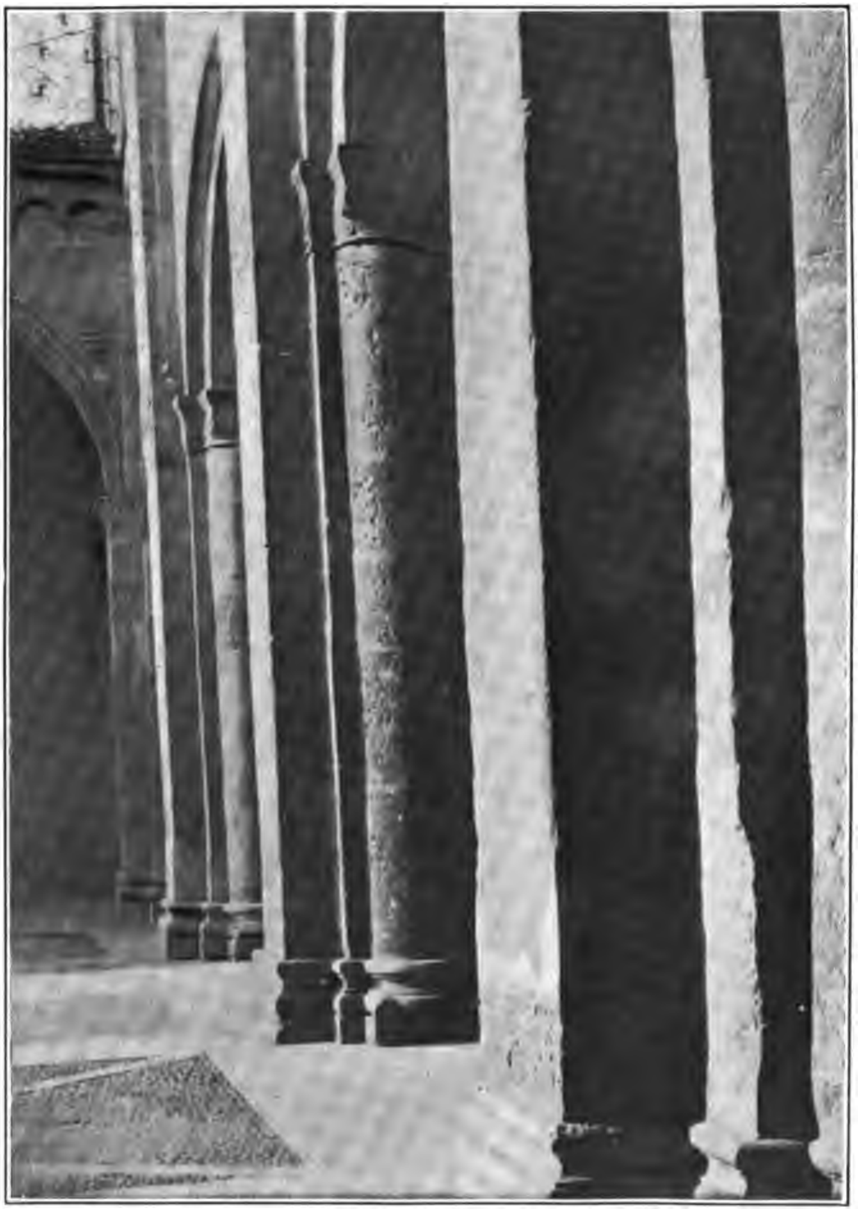

FIG. 10. THE LEANING FAÇADE OF S. AMBROGIO, MILAN.

The lean amounts to 9 inches for the first story. Photograph of the Brooklyn Institute Survey, 1901.

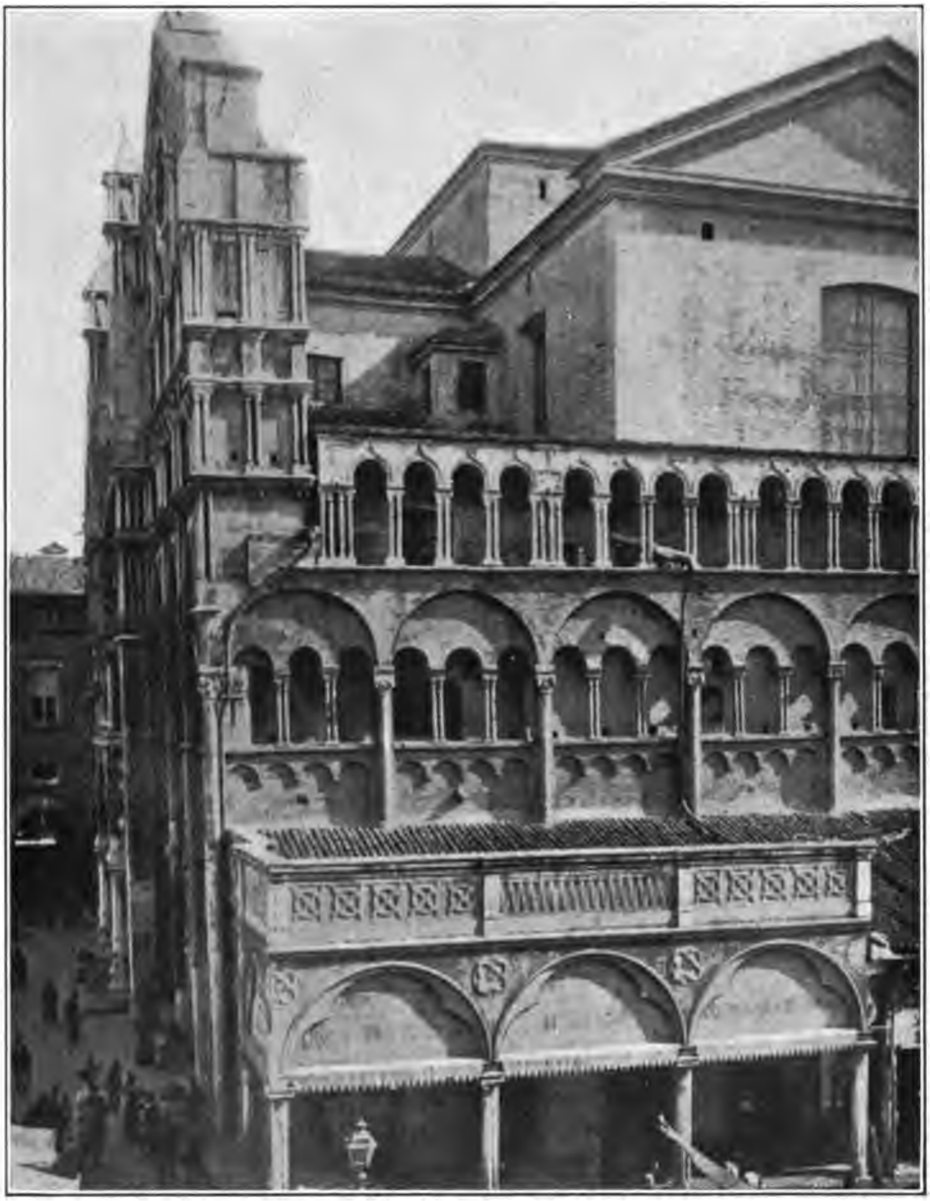

FIG. 11. THE LEANING FAÇADE OF FERRARA.

The lean amounts to about 22 inches in 96 feet. Photograph of the Brooklyn Institute Survey, 1901.

ration, and the avoidance of foreshortening was palpably intended. The instance to be finally mentioned is among the most important, because the constructive facts are now attested by an architect's certificate and because they have been so long ignored in the case of a church as famous as S. Mark's at Venice.

This instance was first observed in 1870, and was again observed in 1895. Publication was made in Vol. VII., No. 3, Architectural Record, but with a very unsatisfactory photograph. Four photographs were made in 1901, all of which show the plumb line. Figs. 12 and 13, are selected from them.

All the columns of the façade of S. Mark's on the lower story, lean out in similar fashion, excepting those at the southwest angle, which have been repaired by an architect now deceased, and ignorant of this refinement. The plumbs show tips varying from 2¼ to 3½ inches in a height of 9½ feet. The walls behind these columns are perpendicular. The columns of the upper row are perpendicular.

When these facts were pointed out, in 1901, to Commendatore Pietro Saccardo, the engineering architect then in charge of S. Mark's, he instantly recognized them as constructive, although he had not previously noticed them. He also furnished me with a certificate regarding the construction. This certificate is reserved on account of its inclusion of other phenomena, and will shortly be published in Vol. I., No. 2, of these Memoirs.*

Although in this instance it is the columns which lean forward and not the wall, the facts are analogous to those shown by the bending or curving fronts of Pisa, Pavia and Milan. There is, however, this distinction. If the avoidance of foreshortening were the only consideration here, it would seem that the upper row of columns would also lean out. At Pisa, Pavia and Milan, and in Notre Dame, we might suppose the return to the perpendicular to be due to considerations of stability, but this consideration could not be imagined to apply to the façade columns of the second row in S. Mark's, because there was no sacrifice of stability in the tilt of the lower columns; the wall itself being perpendicular. The bend in the vertical would therefore appear to have been the controlling consideration, in this instance, and an aversion to the rigidity of the straight line would therefore be the proper explanation. This may consequently also apply to the cases at Pisa, Pavia and Milan.

This probability is strengthened by the interesting observation of Commendatore Pietro Saccardo, as to the forward tipping pinnacles and statues of St. Mark's, and as to the forward tip of the Porta della Carta. Since the pinnacles tip by construction the perpendicular position of the second line of columns on the façade must be certainly significant of the preference for a bending vertical at that point. Otherwise they would also tip forward. On the other hand, the forward tip of the pinnacles and statues could only be explained as intended to avoid foreshortening. This must also be the explanation for the Porta della Carta.

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*The original has been published in the Journal of the Archæological Institute of America, Vo. VI., No. 2. New Series.

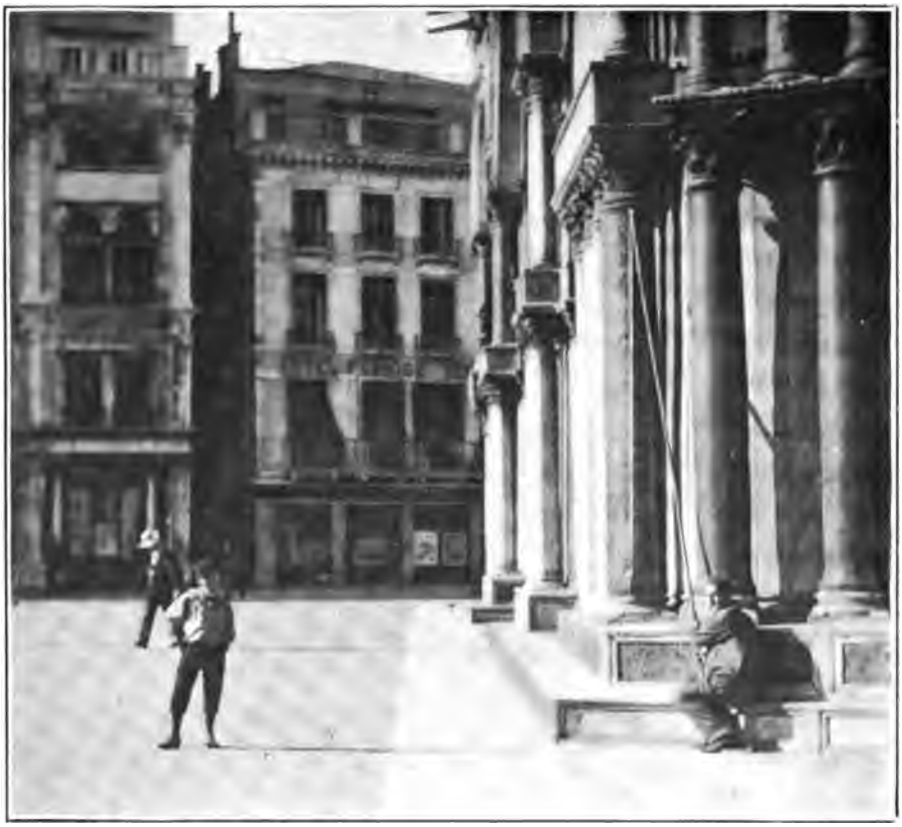

FIG. 12. THE LEANING COLUMNS OF S. MARK'S FAÇADE, VENICE.

The leans vary from 2¼ to 3½ inches in a height of 9½ feet. The upper columns are perpendicular, as is the wall behind the leaning columns. Photograph of the Brooklyn Institute Survey, 1901.

The forward tip of the pinnacles was personally made known to me by Commendatore Saccardo as being about 6½ inches. We plumbed the Porta della Carta together, and found the tip to be 8 inches.

The fact that the architect, now deceased, who formerly controlled the repairs of S. Mark's did not understand, and did not repeat, the artifice of the original builders during his repairs was mentioned to me by Commendatore Saccardo. He also informed me

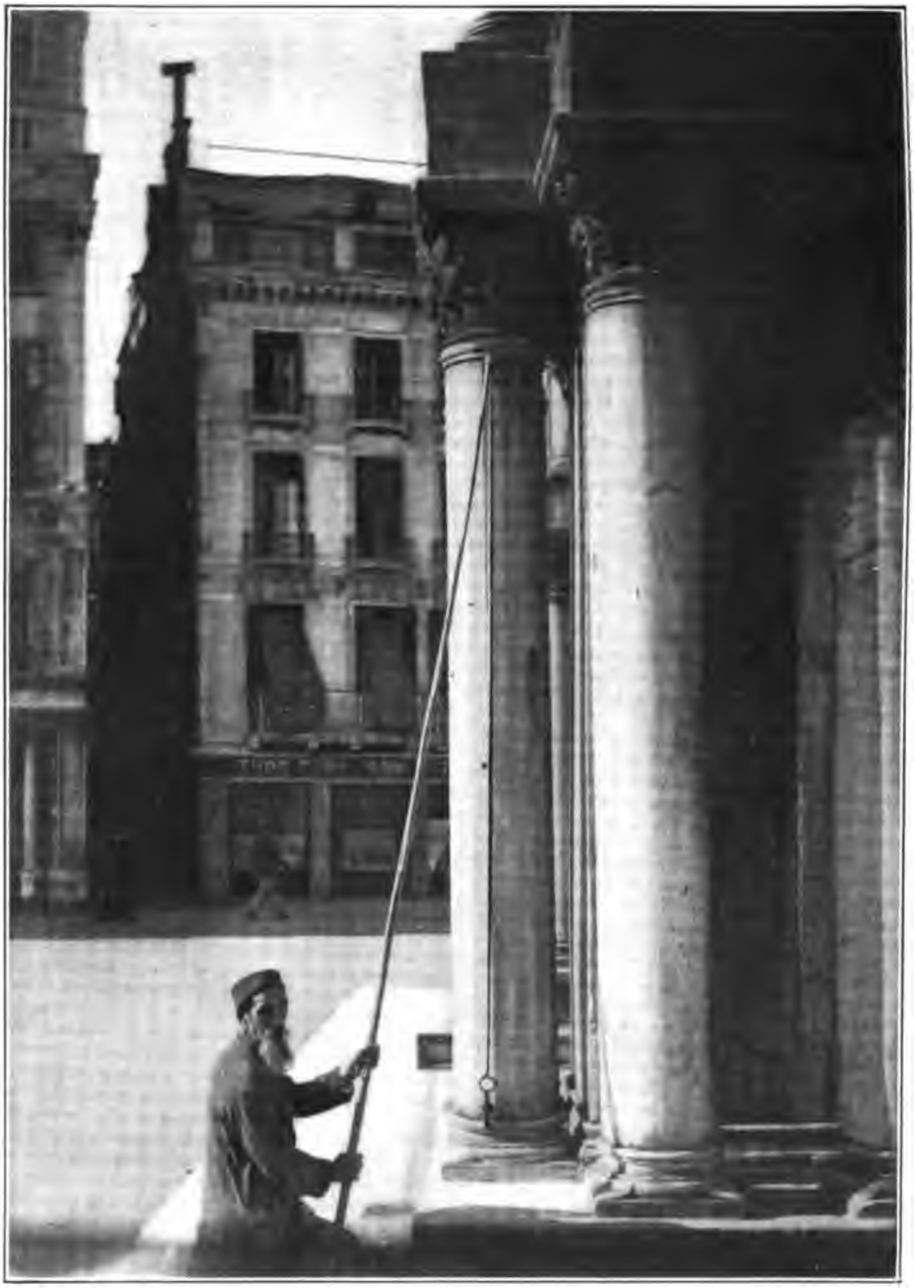

FIG. 13. THE LEANING COLUMNS OF S. MARK'S FAÇADE, VENICE.

The leans vary from 2¼ to 3½ inches in a height of 9⅓ feet. The upper columns are perpendicular, as is the wall behind them. Photograph of the Brooklyn Institute Survey, 1901.

that he was at this time a subordinate of the official in question, and that a controversy between them was caused by his contention that the repairs of the side façades had not been carried out according to the methods of the ancient builders. This controversy was carried into the Venetian daily newspapers and continued for ten days (1881). An account of this controversy will be found at p. 5 of a monograph by Commendatore Saccardo, entitled, "I Restauri della Basilica di San Marco nell' ultimo decennio," (Venezia, Tipografia Emiliana, 1890).

We now return to the consideration of the leaning façade of S. Ambrogio at Genoa, with the following conclusions:

(a) If the tradition regarding such a practice disappeared, as it did disappear, after 1600, there is no reason why the tradition should not have disappeared, for earlier buildings, such as the Pisa Cathedral; and one ground of incredulity regarding mediæval instances, viz.: the supposed unprobability that such a thing should have been done and then forgotten, no longer exists.

(b) The suggestion has sometimes been verbally made that the builders of the Middle Ages were not familiar with the ordinary mechanical methods of rectilinear building, but the builders of the late Renaissance have never been accused of lacking in formal accuracy. Therefore, if they did, for a purpose, deviate from the normal perpendicular, in one instance, there is no reason why the builders of the Middle Ages should not have deviated from the normal perpendicular, for the same purpose, or for some other purpose, in other instances. In fact, the isolation of the Renaissance example can best be explained as a rare survival of a practice which once had greater currency. It is especially for this reason and as bearing on the announcements which have been previously made for mediæval buildings that this paper is published.

Museum of the Brooklyn Institute of Arts and Sciences.
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MEMOIRS OF ART AND ARCHÆOLOGY

Vol. I: No. 2.

THE ARCHITECTURAL REFINEMENTS OF ST. MARK'S AT VENICE

With Remarks on other Churches Showing a Similar System of Leaning Verticals; Especially those in Orvieto, Vicenza, Milan, Pavia, Bologna, and Arezzo, and Including the Renaissance Church of S. Giorgio Maggiore at Venice.

BY
WILLIAM HENRY GOODYEAR

WITH FOURTEEN PLANS AND FORTY-FOUR ILLUSTRATIONS

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DECEMBER, 1902

THE ARCHITECTURAL REFINEMENTS
OF
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Preface.

In the Diary of John Evelyn there is a passage relating to the architectural commission which was appointed, in the reign of Charles the Second, to examine and report upon the old Gothic Cathedral of St. Paul's in London. Evelyn was a member of this commission, which was headed by Sir Christopher Wren. The entry is found under date of July 27th, 1666. The cathedral was destroyed soon after, by the fire of London. Here is the passage:

"I went to see St. Paule's church, where, with Dr. Wren, Mr. Prat, Mr. May, Mr. Thos. Chichley, Mr. Slingsby, the Bishop of London, the Deane of St. Paule's, and several expert workmen, we went about to survey the generall decay of that ancient and venerable church, and to set down in writing the particulars of what was fit to be don, with the charge thereof, giving our opinion from article to article. Finding the maine building to recede outwards, it was the opinion of Mr. Chichley and Mr. Prat that it had been so built ab origine for an effect in perspective, in regard of the height; but I was, with Dr. Wren, quite of another judgment, and so we entered it; we plumbed the uprights in several places."

It was about 1879 that this passage first attracted my attention, as having some possible relation to an observation which had been made in Venice in 1870. In that year it was noticed that the casing of certain piers in St. Mark's had been cut obliquely, so as to fit and correspond with a system of vertical inclinations which also "receded outwards." The leans of the piers could, therefore, not be less ancient than the casing itself.

This casing was undoubtedly ancient. Inasmuch as accidental movements and settlements of the building would probably not all have taken place at once, immediately after the rough construction was finished and before the casing was applied, this again would argue that the leans were constructive.

The note-book of 1870, in which this memorandum was entered, is still extant. So also is a printed syllabus of 1879, in which this observation was recorded. It was not, however, until 1887, that a photograph of the interior of S. Maria della Pieve at Arezzo furnished an additional suggestion that a system of constructive refinements in the matter of leaning verticals which "recede outwards," might be discovered in the architecture of mediæval Europe.

Photographs are notoriously insufficient evidence as to the lean-

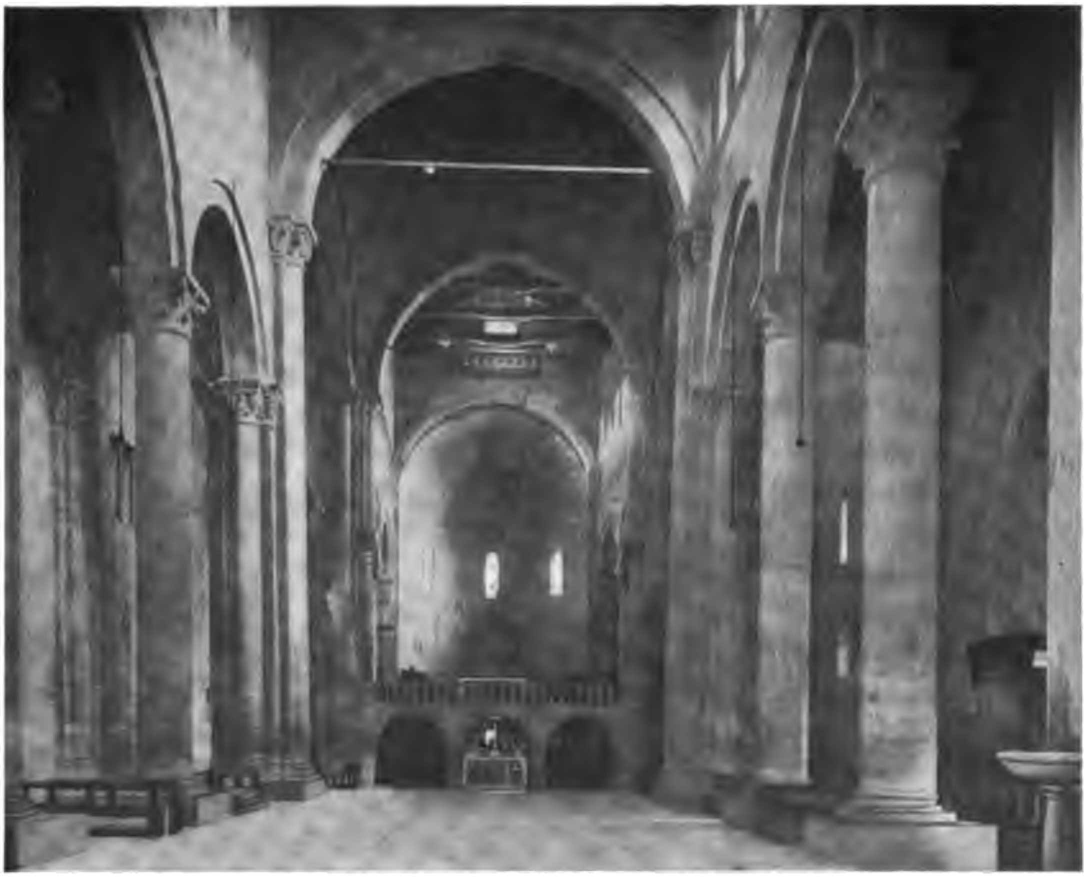

FIG. 1. SANTA MARIA DELLA PIEVE, AREZZO.
From a photograph of the Brooklyn Institute Survey, 1895. The widening in the piers at the transept is about 28 inches.

ing lines of an interior, unless they are made with great care, and a slight tilting of a camera would produce a distortion. The photograph which was examined in 1887 was therefore not regarded as evidence. It was considered purely as a memorandum, making advisable a personal examination of the church itself. This examination was made in 1895.*

A tentative and preliminary examination of the church was made on the dates of July 18th, 19th, and 20th, in company with an architectural assistant. A second visit was made on the dates of August 16th, 17th, 18th, with two assistants, one of whom was an experienced surveyor and engineering architect, and at this time photographs were carefully taken and reliable estimates of the amount of inclination were made (Fig. 1). The ground-plan of the church was also surveyed.[*]

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*During a prolonged surveying trip of six months in which many other phases of asymmetrical mediæval construction were studied. For the general results of this survey see the list of publications on the third page of the cover.

It was during the later part of the trip of 1895, and subsequent to the Arezzo observations, that the evidence for the constructive existence of this "outward receding" in mediæval architecture was considerably enlarged. In St. Mark's, at Venice, the scanty and hasty observations of 1870 grew into a definite and well-established certainty.

During a six days' stay in Venice (Sept. 6th-11th), many photographs were carefully taken, so as to serve as an exact record concerning the leaning verticals and a few plumb measurements were made. The questions of construction were carefully considered by the engineering expert, Mr. John W. McKecknie, who had been employed by the Survey for such purposes.

Most important observations as to this particular phenomenon were also made during the month of October, 1895, after Mr. McKecknie's departure for the United States, in Pavia, Milan, Borgo San Donnino, and Cremona; but these observations were not corroborated by photographs or by any systematic record of measures, owing to the unusual haste involved in the effort to visit a large number of localities before a fixed sailing date.

After return to the United States it appeared that two of the survey photographs, which had been carefully taken to an exact level and perpendicular, in churches where other refinements had been noticed and surveyed, also supplied the evidence of this refinement. These churches were the Cathedral of Trani and the church of Ss. Giovanni e Paolo at Bologna.

In the Cathedral of Trani the piers of the great arch crossing the nave at the transept recede outwards 12 inches and the very slight thrust of the arch above them is resisted by the entire depth of the transept walls (Fig. 2).

In the church of Ss. Giovanni e Paolo at Bologna (Fig. 3) the clerestory walls recede outwards 10 inches and they are tied in by a transverse wall at the apse, so that accidental outward movement at this point, where the full widening continues, would be impossible.[†]

Thus, in 1897, it was possible to publish a summary of the evidence which had been secured up to that time on this matter, and inasmuch as the old literary record, which has been quoted, now seemed to have gained considerably in significance, this publication was given the title of "An Echo from Evelyn's Diary."[‡]

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[*] Architectural Record, Vol. VII., No. 2, 1897; p. 210.

[†] This church was revisited in 1901, and the facts which were originally discovered in a survey photograph were verified by personal observation.

[‡] Architectural Record, Vol. VII., No. 2, 1897.

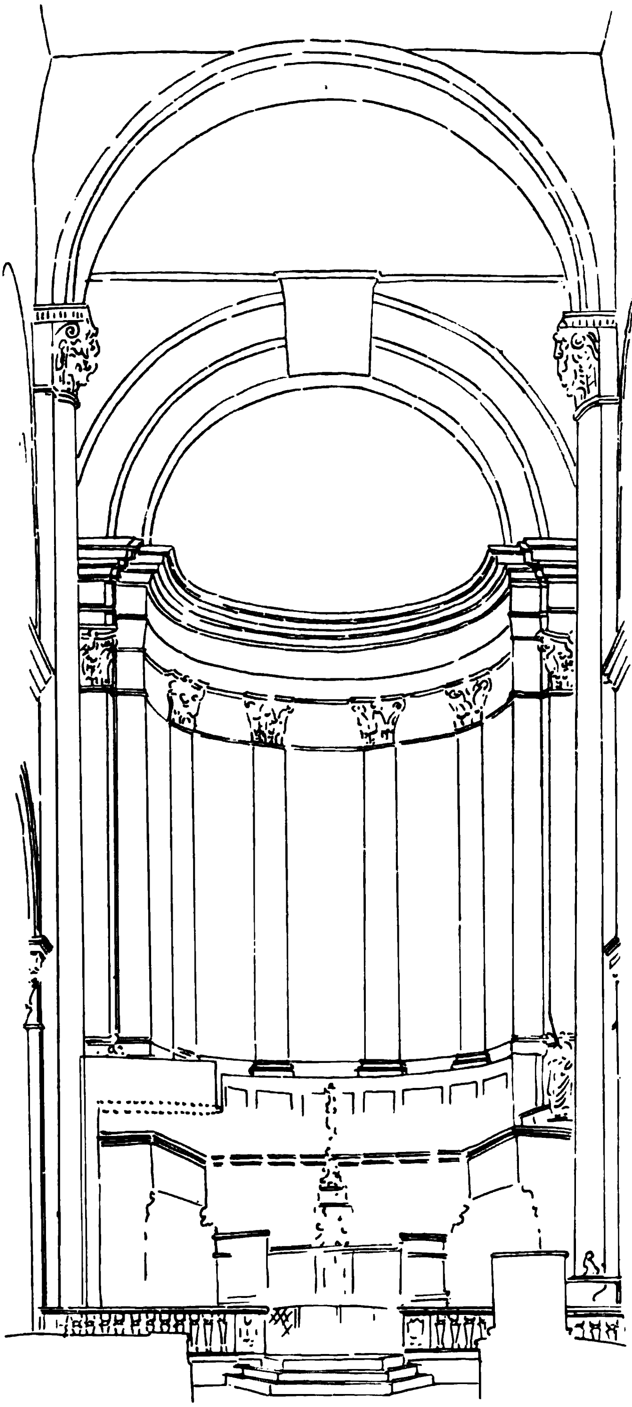

FIG. 2. CATHEDRAL OF TRANI. ARCH SPANNING THE NAVE.

Tracing from a Survey photograph of 1895. The widening in the piers of the arch is about a foot. The walls of the nave curve inward near the ceiling. The original lines of the apse are concealed by Renaissance stucco.

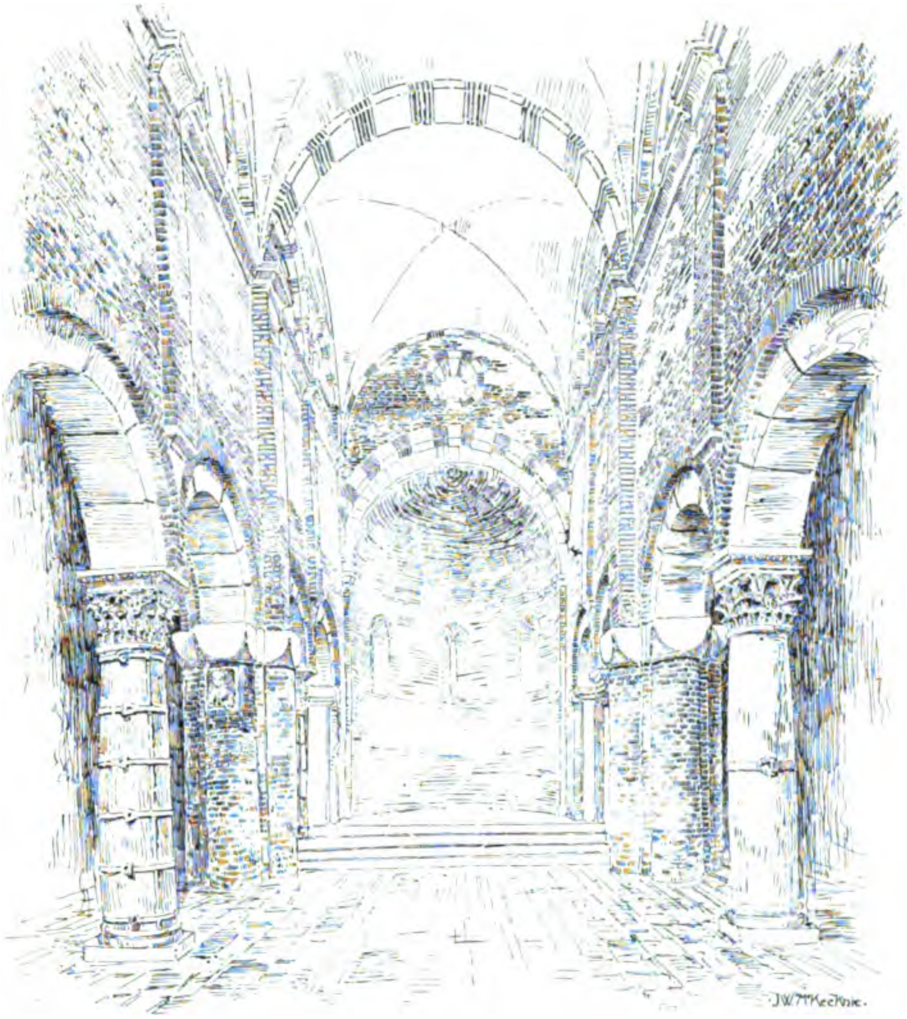
J.W. McKecknie.

FIG. 3. SS. GIOVANNI E PAOLO, BOLOGNA.

Drawing over a Survey photograph of 1895. The widening in the walls of the nave is 10 inches, and this widening extends to the point where the clerestory walls are tied in by the wall of the apse.

There was still much to be done, even in a preliminary study of this matter. In 1895 our surveying party had employed a well-qualified engineering expert, and his certificate had been published regarding the constructive facts in S. Mark's and at Arezzo, in the paper which has just been cited. Notwithstanding, it appeared that a certificate from the engineering architect in charge of St. Mark's was also to be desired.

It was especially in order to secure this certificate that a trip to Italy was made in 1901. An additional motive for this visit was the wish to verify and corroborate by photographs and measurements, the hasty and insufficiently substantiated observations of 1895, in Pavia and Milan. The result was, however, not only to make good the deficiencies of record for the evidence already known to exist, but also to secure wholly unexpected additional evidence of a character which will doubtless challenge the attention of every architectural expert.

From this point of our Memoir the evidence will be massed, without regard to the date at which it was obtained. But the reason for this method of approach to the topic lies in the appeal which it suggests for future research; based on the positive certainty, which has now been attained, that the churches which have been found to show this remarkable construction are not the only ones.

Since the survey photographs of S. Maria della Pieve at Arezzo have been the first referred to, it is well to add that this church has been chosen for an important preliminary illustration (Fig. 1), not only because it was the pivot from which our search for the given refinement moved in 1895, with a certainty that somewhere or other, churches with similar phenomena would again be found, but also because it is a peculiarly marked and definite case, and therefore one in which the diverging lines can easily be shown by a photograph.

This again makes it important to say that what is easily seen in a photograph is not always easily seen in a building. The photograph which is accurately made to show an obliquity, or lean, often produces an impression on the observer which is wholly foreign to that actually found in the building. In the buildings themselves these leans are inconspicuous. They are discounted, or translated by the eye, into other effects, whereas the photograph may appear abnormal.

A remarkable indication of the absence of an abnormal appearance in the buildings is the fact that these leans have not been published as constructive. Thus these verticals "receding outward" really do partake of the nature of a refinement; i. e., they are inconspicuous, although they may not so appear to be, in the case of the Arezzo photograph.

On the other hand, certain photographs of St. Mark's approximate to the effect obtained in the building and may assist the student to understand the motive of this construction. On the whole, however, the purpose of this refinement should be studied in the buildings and not in the survey photographs. These are simply illustrations of the existence of such leaning verticals; having been made with all possible precautions to avoid the distortions which are due to the tilting of the photographic plate. Moreover, in the most important cases their evidence is supported by measures with the plumb-line.

As to the purpose of this remarkable constructive system, it may grow to be as much debated, and continue to be as little understood, as the Greek horizontal curves themselves.* It is perhaps not even clear at present, in what sense the suggestion of Chichley and Prat, as quoted by Evelyn, should be taken,—"that it had been so built ab origine, for an effect in perspective, in regard to the height." The main purpose of this publication is to so bring the facts to the knowledge of experts that their views may be obtained. Meantime, it has already been suggested by the writer that one purpose may have been to avoid the contracted and spindling effect which the perspective convergence of vertical lines tends to produce in a lofty nave. There are also several churches, and St. Mark's is one of them, in which the effect may be compared to an emphasized development of that entasis, or vertical curve, which has been proven by the Brooklyn Institute surveys to occur in the piers of some mediæval churches. There is a palpable grace and suavity, a largeness of sweep and an elegance of design about these bending verticals which may be their all-sufficient explanation.†

At present the important point is to collate as many facts as possible and what remains to be said in this paper as to possible motives will be best said after all the known facts have been presented.

No discussion on the point of motive could, however, be satisfactory which does not consider the evidence which has been elsewhere presented for the existence of other phases of architectural refinements in mediæval churches.

The Constructive Evidence at Orvieto and Vicenza.

It is self-evident that outward leaning walls or piers in vaulted churches are presumably to be attributed to accidental causes and that they are to be attributed especially to thrust from the vaulting, unless positive proof to the contrary be furnished. We shall therefore address ourselves to the proofs that the given facts are constructive in certain churches to be named.

For instance, in the Gothic church of S. Agostino at Orvieto the walls lean outward, while buttresses of the same age, and of homogeneous construction with the wall, lean inward. This shows, of course, that the walls do not lean outward accidentally. Several photographs of this church were made on Sept. 17th, 1901, and a drawing from one of them is published in Fig. 4. An enlargement of 25 × 35 inches from this photograph is exhibited in the Museum

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*For the various theories which have been advanced as explanations of the Greek horizontal curves, see Journal of the Archæological Institute of America, Vol. VI., No. 2, New Series, 1902; Goodyear; "Architectural Refinements in Italian Churches."

†A very remarkable demonstration for the constructive existence of delicate curves in mediæval piers has been found in the Cathedral of Vicenza. See the Journal of the Archæological Institute of America, Vol. VI., No. 2, New Series, 1902. See also p 47 of this Memoir.

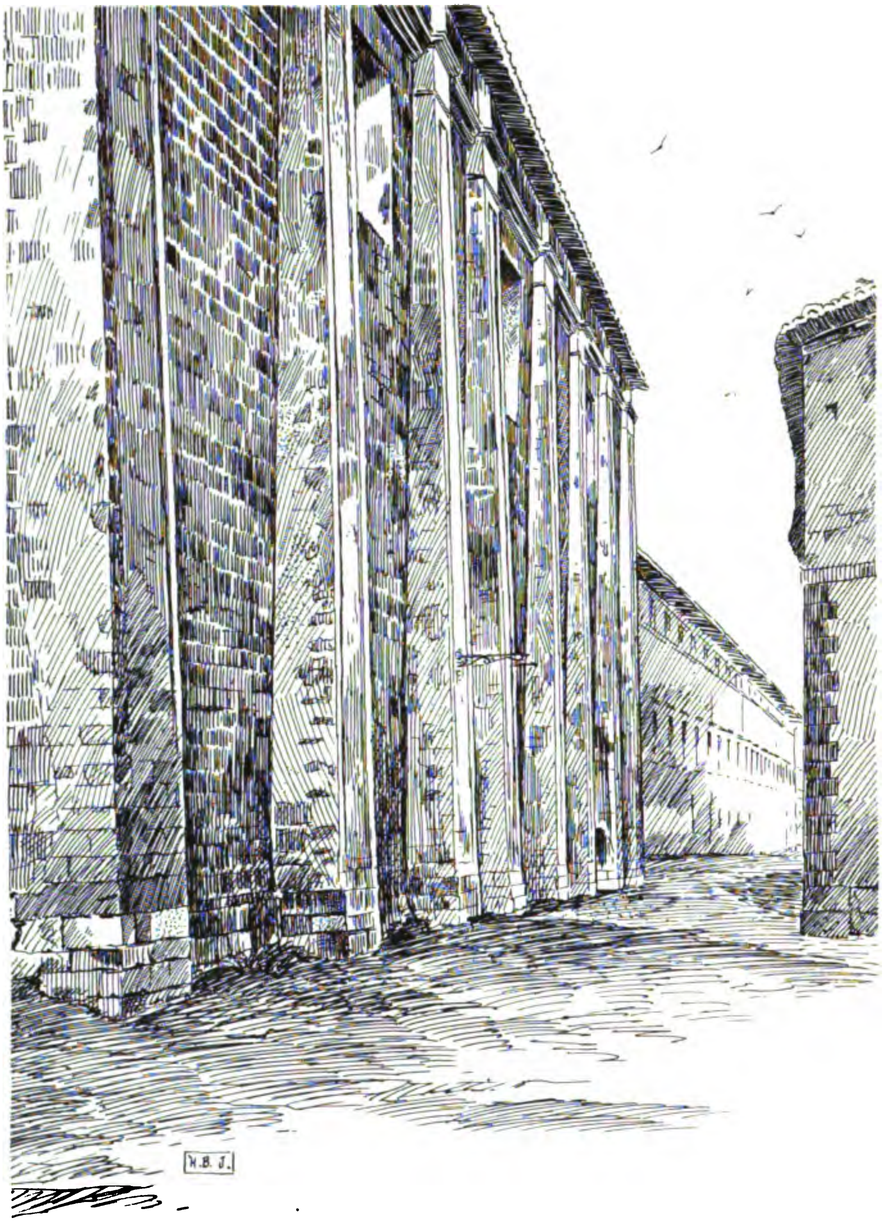

FIG. 4. S. AGOSTINO, ORVIETO.

Drawing from a Survey photograph of 1901. The interior widening is shown in the exterior outward leaning wall. The buttresses lean inward and are a portion of the original construction.

of the Brooklyn Institute. In such enlargements the facts are shown with much greater clearness than in the small dimensions of these pages.

The church is now in possession of the military authorities at Orvieto and the temporary absence of the Commander made it impossible for me to examine the interior, although I had visited Orvieto expressly to make these photographs.

The exterior of this church, then also closed and abandoned as regards the interior, was first examined on July 10th, 1895, but I did not then realize its importance, being absorbed in a survey of the Orvieto Cathedral, and in a study of quite different phenomena.* At that time, my conception of the outward receding verticals was that they would be confined to the clerestory or to the piers of the nave as they have since proven to be at Arezzo, Perugia, Bologna and Cremona. It had never dawned upon me that these leans for interior effect, might be found in the exterior walls of a church. S. Agostino at Orvieto seemed at that date to be a species of freak. It was not till 1901 that the discovery of a similar case in Vicenza led me to revisit Orvieto in order to make these photographs.

On Sept. 2d, 1901, the Gothic church of S. Lorenzo in Vicenza (Fig. 5) was observed to have exterior side walls leaning outward against buttresses of the same age, and of homogeneous construction with the walls, which had outer perpendicular faces. This construction proved to be the exterior phase of an interior outward leaning of the aisle walls.

Several photographs were made in the interior and plumbs were taken at various points. The original of Fig. 6 was taken so as tc show the inner side of the wall which appears in the exterior of Fig. 5. The lean continues at the angle of the transept wall, which has a depth of 10 feet.

At this point no movement due to thrust is conceivable, and we have thus an additional corroboration for the constructive facts as shown by the exterior buttresses.

The lean amounts to 6 inches in a height of 32 feet, at the angle, and it amounts to 9 inches at the pilaster which is nearest to the spectator in the photograph.

In the greater height of the exterior wall the lean amounts to about a foot. The thickness of the wall itself is 4 feet and the buttresses project 3 feet from the bottom of the wall. Similar facts are found in the left aisle and a photograph has been taken to represent them.

Fig. 7 shows the nave of the same church, taken from the High Altar, and looking toward the façade. The outward receding, or spreading, in this nave, begins in the clerestory walls. It only

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*Architectural Record, Vol. VI., No. 3, p. 309.

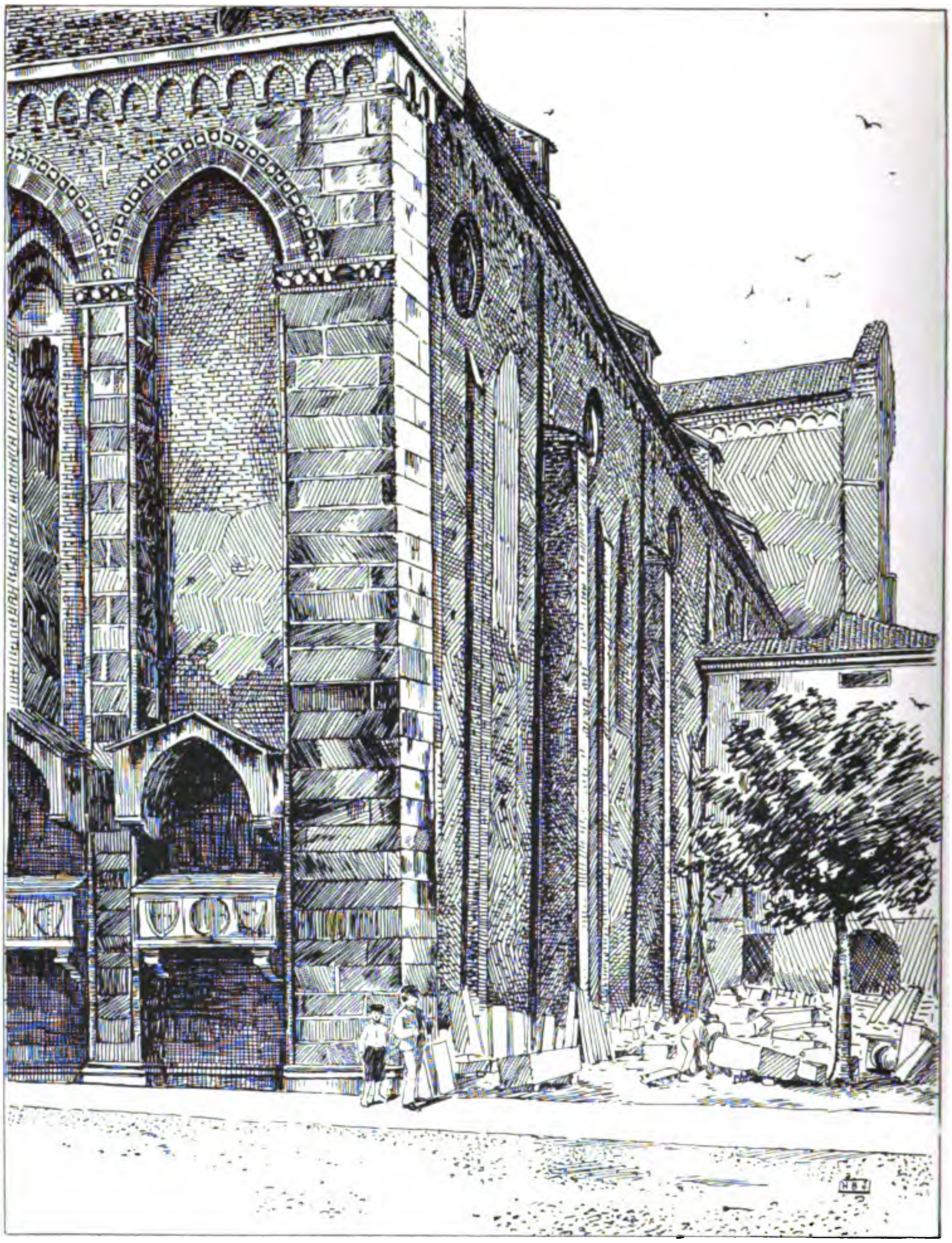

FIG. 5. S. LORENZO, VICENZA.

Drawing from a survey photograph of 1901. The interior widening is shown in the exterior outward leaning wall. The outer faces of the buttresses are perpendicular, and they belong to the original construction.

amounts to about 3 inches on each side in a height of 16 feet; a total divergence of 6 inches. The delicacy of feeling which called for this divergence is certainly remarkable, but we shall find proofs in more than one building that leans of as small an amount as 0.10were systematically made for heights of 10 or 12 feet.*

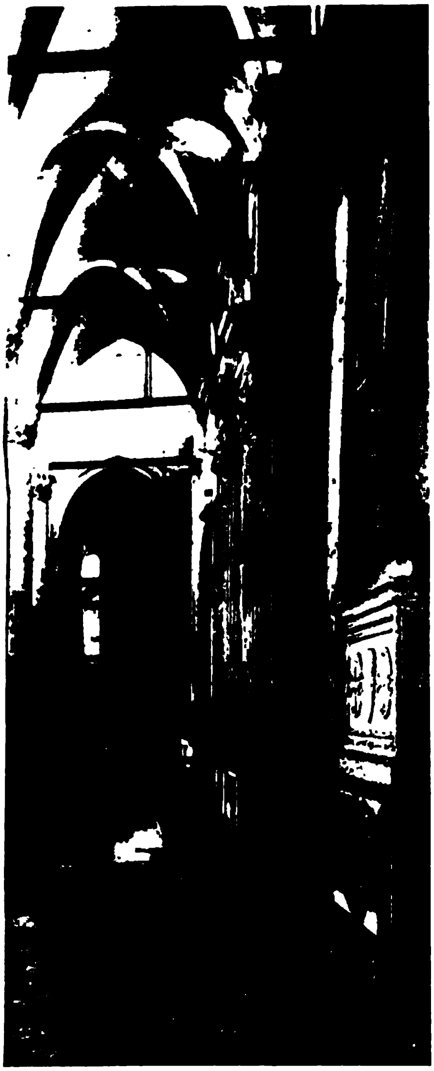

FIG. 6. S. LORENZO, VICENZA.

From a Survey photograph of 1901. Wall of the right aisle, looking toward the transept. The outward leaning is partially obscured by Renaissance monuments. It amounts to 9 inches at the first pier on the right, and to 6 inches at the angle of the transept wall, in a height of 32 feet.

S. Agostino at Orvieto and S. Lorenzo at Vicenza are the only buildings, so far observed, in which the outside walls of the building lean out, in connection with a system of interior leaning verticals, but the aisle walls of St. Mark's at Venice also lean outward, as far as the interior surfaces are concerned, as will be shown presently.

There are five other churches, so far found, in which the effect of the outward lean is built into the pilasters of chapel walls which face the side aisles. Thus, eight churches are known at present in which either the fact or the effect of an outward lean is carried into the vertical lines of the side aisles.

The five churches above mentioned are: S. Giorgio Maggiore, at Venice; S. Ambrogio and S. Eustorgio, Milan; S. Michele and S. Francesco, Pavia.

The Constructive Evidence at Milan and Pavia.

The four last mentioned cases were all observed in 1895; but, as already noted, without adequate corroboration or record, on account of hasty observation. All these churches have a system of exterior chapels with walls at right angles to the direction of the aisles and of such depth as to make it positive

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*The view of the aisle (Fig. 6) shows a peculiar treatment of the vaulting, which is indicated by the oblique lines of the timber beams, showing that the capitals are lower on the side of the nave. The vaulting is turned with a higher and shorter curve on the side of the wall and with a depressed longer curve on the side of the nave. The purpose seems to have been to throw the thrust of the vaulting towards the nave and away from the outer wall. A similar treatment of the aisle vaultings is found in the Cathedral of Volterra.

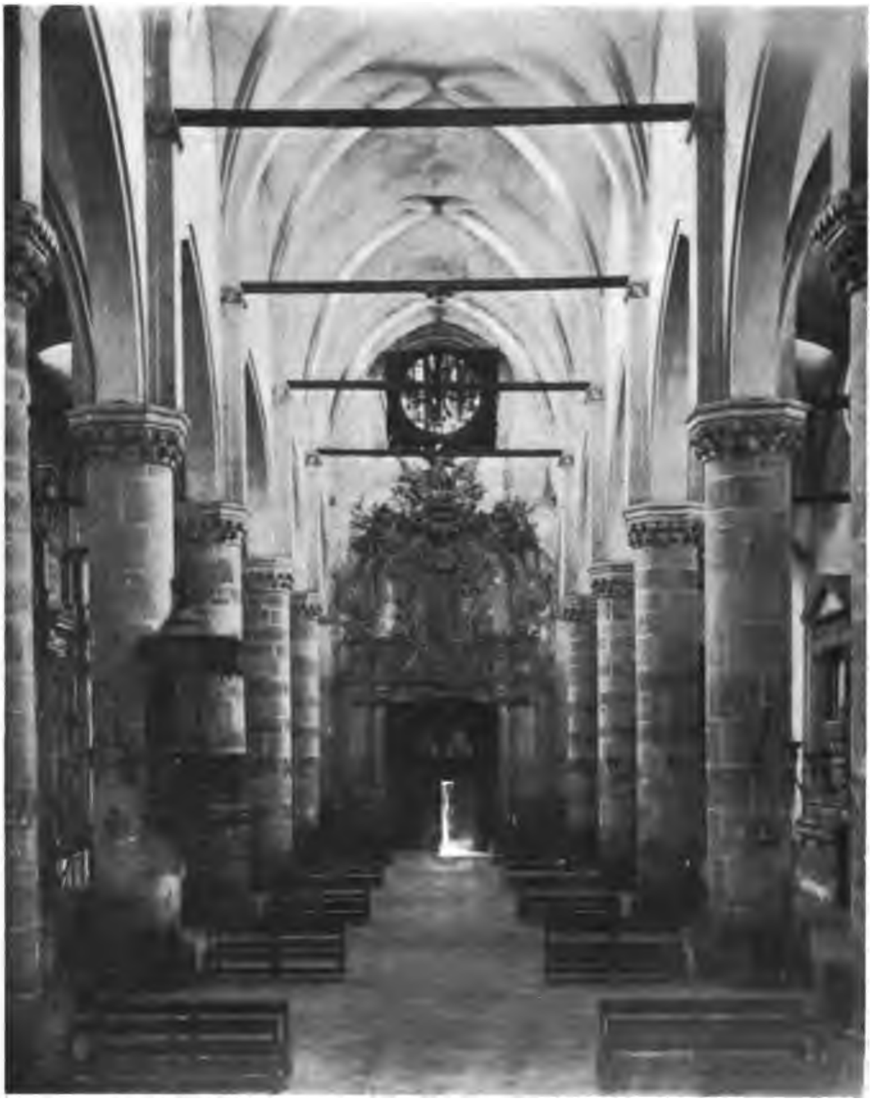


FIG. 7. S. LORENZO, VICENZA.

From a Survey photograph of 1901. The widening, which begins above the capitals of the piers, is estimated at 6 inches in 16 feet.

that the sloping pilasters which face the ends of the walls are constructive.

S. Eustorgio at Milan is an ancient Romanesque church. The slopes of the aisle pilasters, as shown by Fig. 8, were noted on Oct. 9th, 1895. Photographs and plumbs were taken on Sept. 11th, 1901. The slope of the pilaster on which the lamp is hanging is 4½

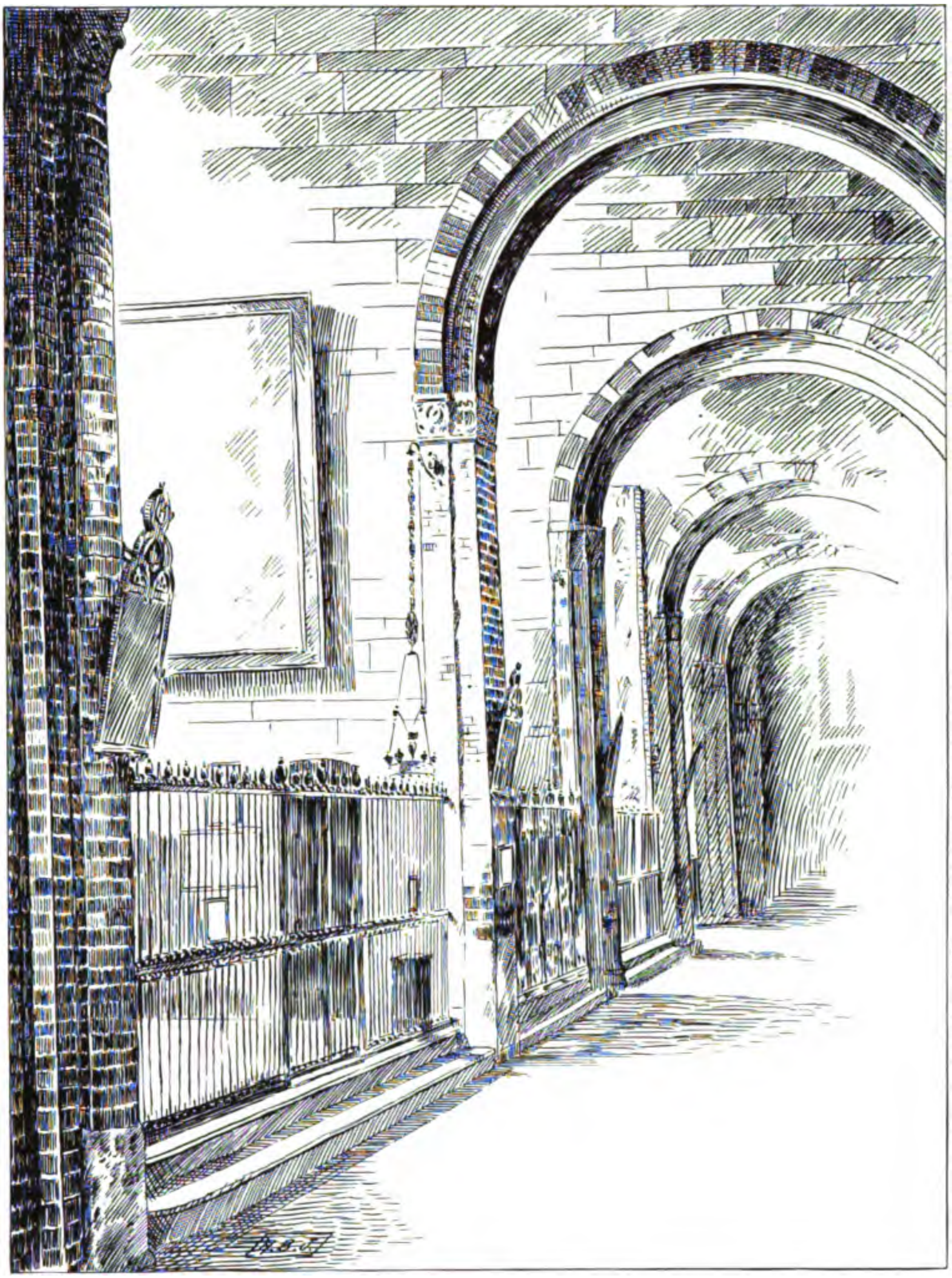


FIG. 8. S. EUSTORGIO, MILAN.

Right aisle, looking toward the façade. Drawing from a Survey photograph of 1901. The average outward lean of the pilasters is 4 inches in 13 feet. All the pilasters of the left aisle have corresponding leans, under similar conditions as regards thrust.

inches in 13 feet. The average slope of six pilasters is 4 inches and the same uniform leans occur in the opposite aisle.

The case of S. Eustorgio is notable because no widening is known to exist in the clerestory of the nave. No sighting was taken from the level of the clerestory, but there is no doubt, at least, that the aisle leans are much the most pronounced in this church. This would show that the aisle spreads were not merely an afterthought or a parallel treatment derived originally from the naves, but that the aisle leans were considered desirable in themselves, without reference to the nave.

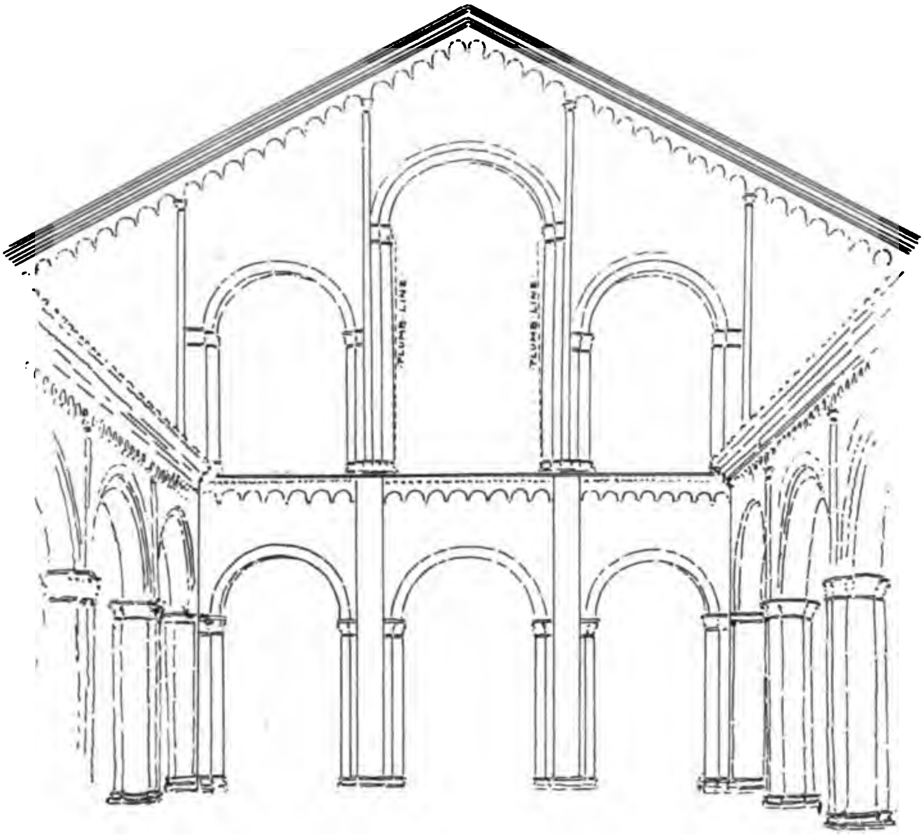
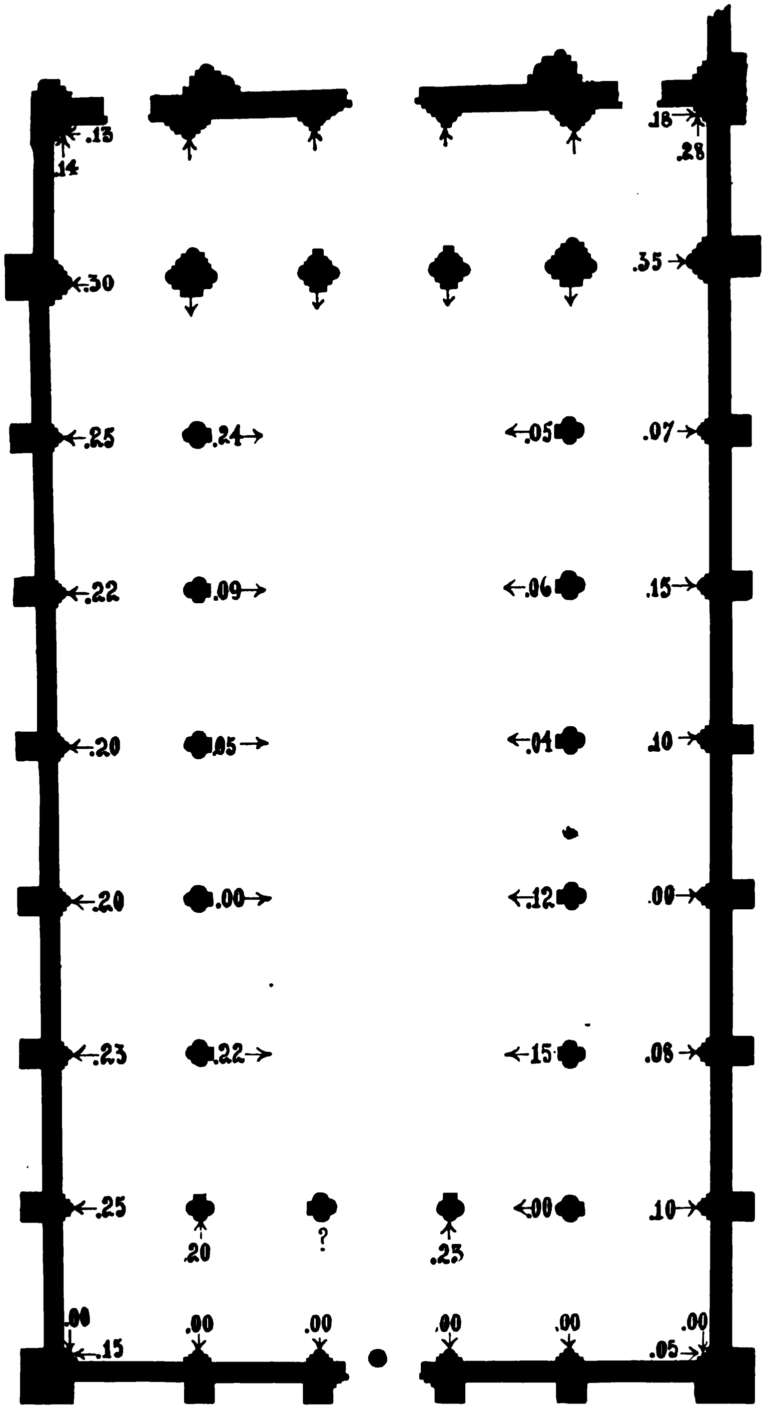


FIG. 9. S. AMBROGIO, MILAN.
The Façade. Tracing from a photograph, to show the widening of the central arch in the upper portico.

Inasmuch as the aisle walls must have been built before the clerestory, it would be conceivable that the building had meantime fallen into the hands of masons who did not practice the given refinement, but it can be otherwise proven that one motive of the



PLAN 1. THE COURT OF S. AMBROGIO, MILAN.

Showing leans in the pilasters of the angles which are parallel with those of the wall pilasters. At the angles of the west wall of the church these leans are double. (Compare Fig. 10.) The measures (in decimals of a foot) were taken with a plumb-line of 13 feet.

debated construction was based on a feeling which was not limited to the effect of a clerestory or of a church aisle. This is shown by the fact that the arcades of the entrance court of S. Ambrogio exhibit this refinement, and so does the central arch of the upper portico of its façade. (Fig. 9.)

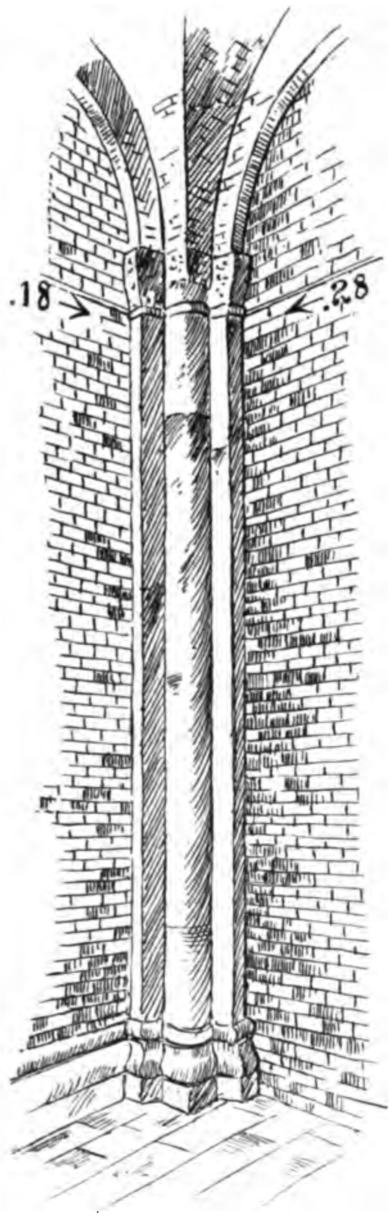


FIG. 10. A PILASTER IN THE COURT OF S. AMBROGIO, MILAN.

Sketch showing the angle of the court near the entrance to the right aisle of the church. The measures representing the lean of the pilaster are to be compared with those of Plan 1, for the other angles of the court. This sketch does not attempt to reproduce the vertical leans. It only represents the conditions under which they occur.

As regards the court of S. Ambrogio; Fig. 10 and Plan 1; we shall confine the proofs for constructive arrangement, as opposed to the natural presumption of thrust, to the observation that the leans are repeated in the pilasters at the four angles of the walls of the court, at points where these pilasters are purely decorative formulas and where no thrust or other accidental movement can be suggested as having affected their vertical directions. The leans in a double direction in the angles of the façade wall of the church, where there is no thrust in either direction, are to be carefully noticed in Plan 1 and Fig. 10. The significance of these leans is, of course, to be related to the fact that they constitute parallels with other leans along the sides of the arcades, which might be open to suspicion as not constructive, if considered without reference to the angles.

In the side aisles of S. Ambrogio (Fig. 11) the evidence for intention is of such a nature that the mere illustration of the facts is sufficient to carry conviction, as it also is in S. Eustorgio. The chapel walls are 21 feet deep (about the same in S. Eustorgio.) Tests with the plumb-line on every pilaster show that the facts are constant and uniform in both aisles. In the illustration of the right aisle the pilaster on which the plumb-line is hanging leans back 2½ inches. The maximum lean in this aisle is 5¼ inches. The average lean is 4 inches.

In the nave; Figs. 12, 13; we find the

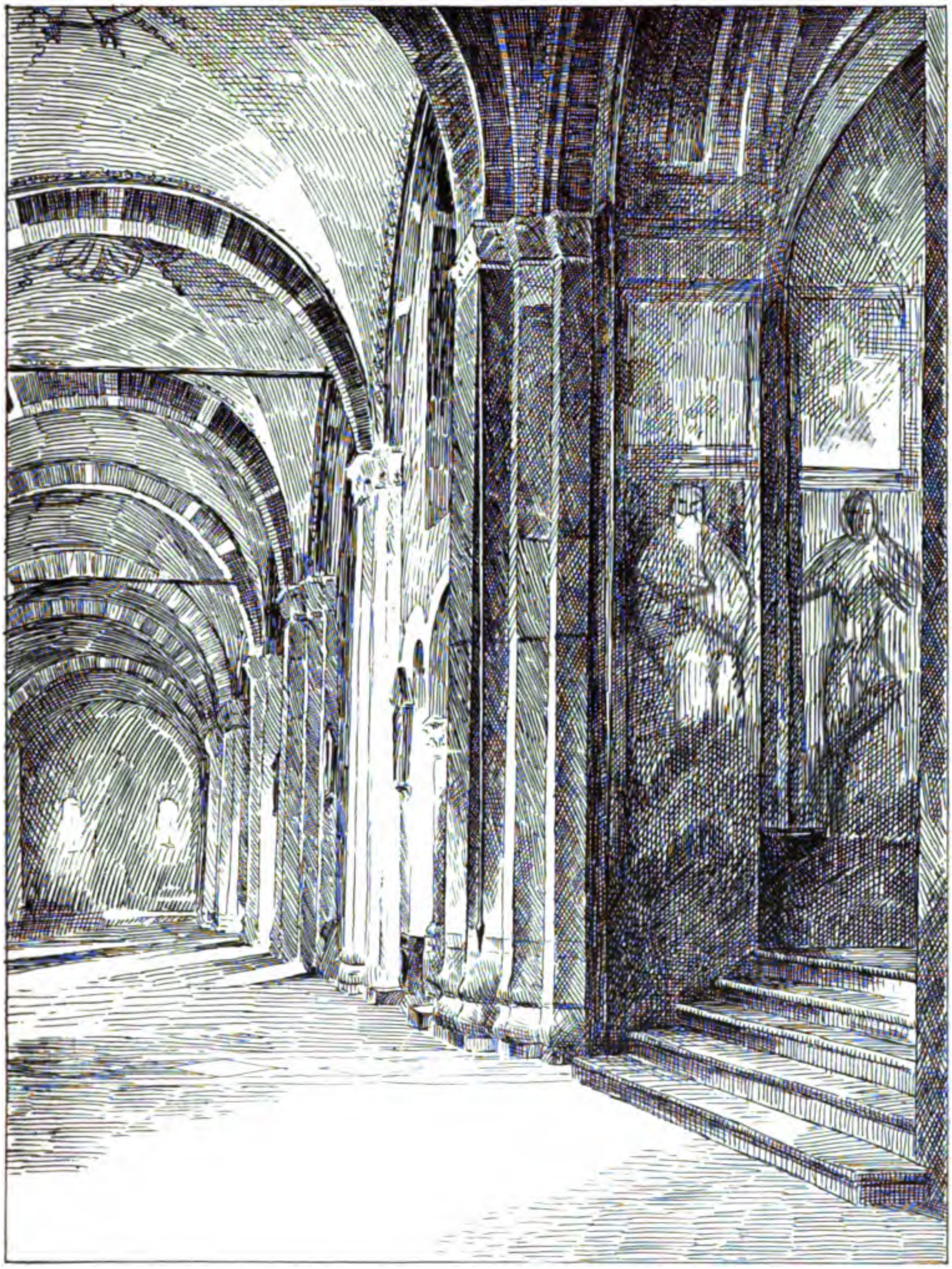


FIG. 11. S. AMBROGIO, MILAN. RIGHT AISLE.

Drawing from a Survey photograph of 1901, showing the plumb-line. The chapel walls have a depth of 21 feet. With a plumb-line of 13 feet the following plumbs were taken in this aisle (foot-decimals): 1st pilaster (extreme right), .20; 2d pilaster (with plumb-line in the drawing), .20; 3d pilaster, .40; 4th pilaster, .44; 5th pilaster, .42; 6th pilaster, .30. The verticals of the left aisle show corresponding inclinations.

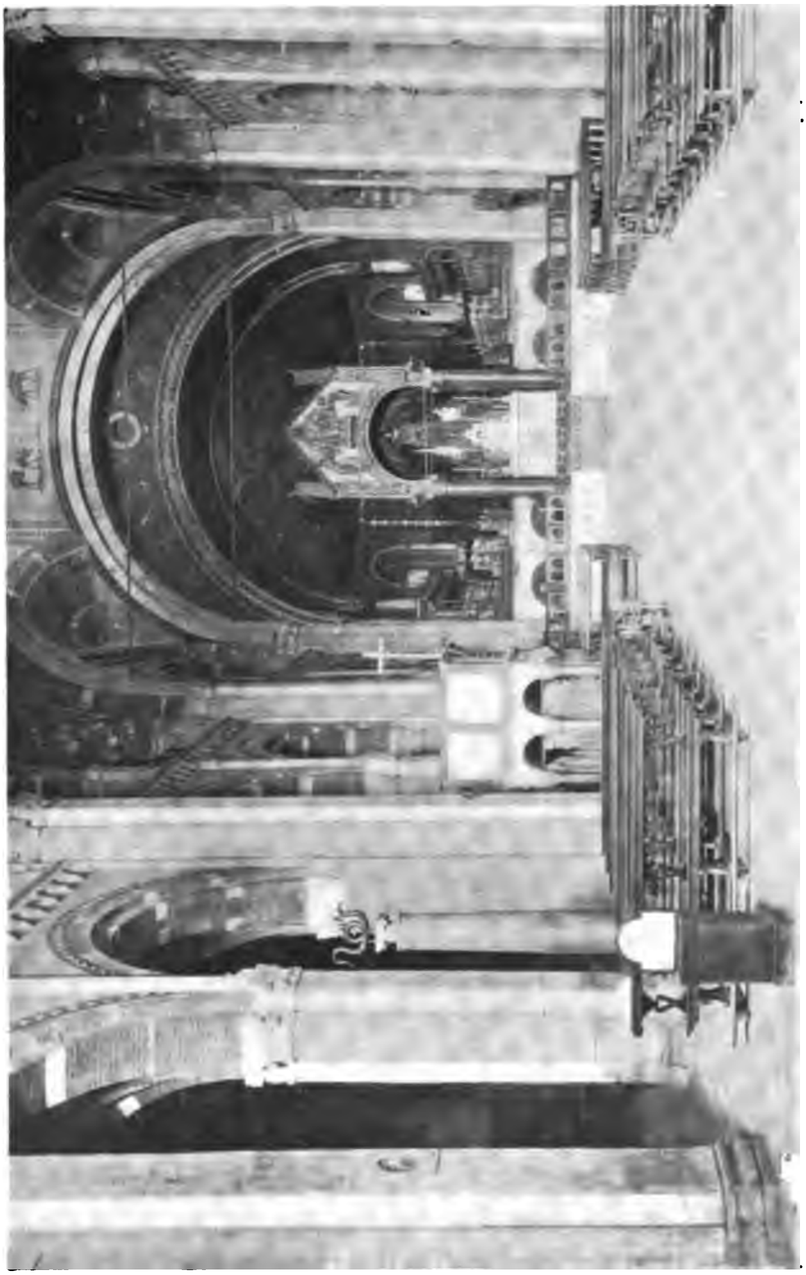


FIG. 12. S. AMBROGIO, MILAN. THE NAVE.

From a Survey photograph of 1901. The piers of the nave vaulting have uniform outward leans, beginning at the pavement, and averaging from 5½ to 6 inches, in a height of 30 feet. Compare Fig. 13.

main piers, which rise to the springing of the vaulting, all constructed with outward receding verticals, and with uniform leans amounting, by plumb measurement from the gallery to the pavement, to 5½ or 6 inches each, in a height of 30 feet. (The alternating piers, which correspond to the smaller bays of the aisles, lean into the nave in some cases. Plumbs from the pavement have still to be taken for several of these alternating piers.)

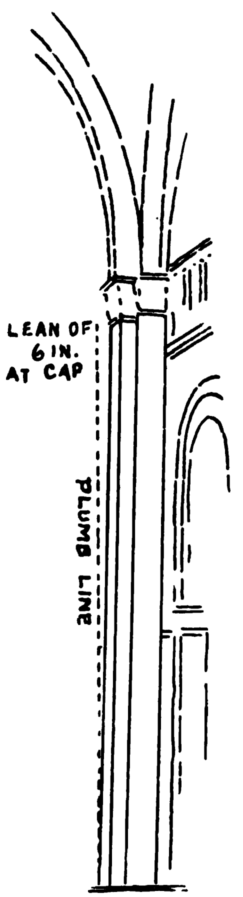


FIG. 13. S. AMBROGIO, MILAN.

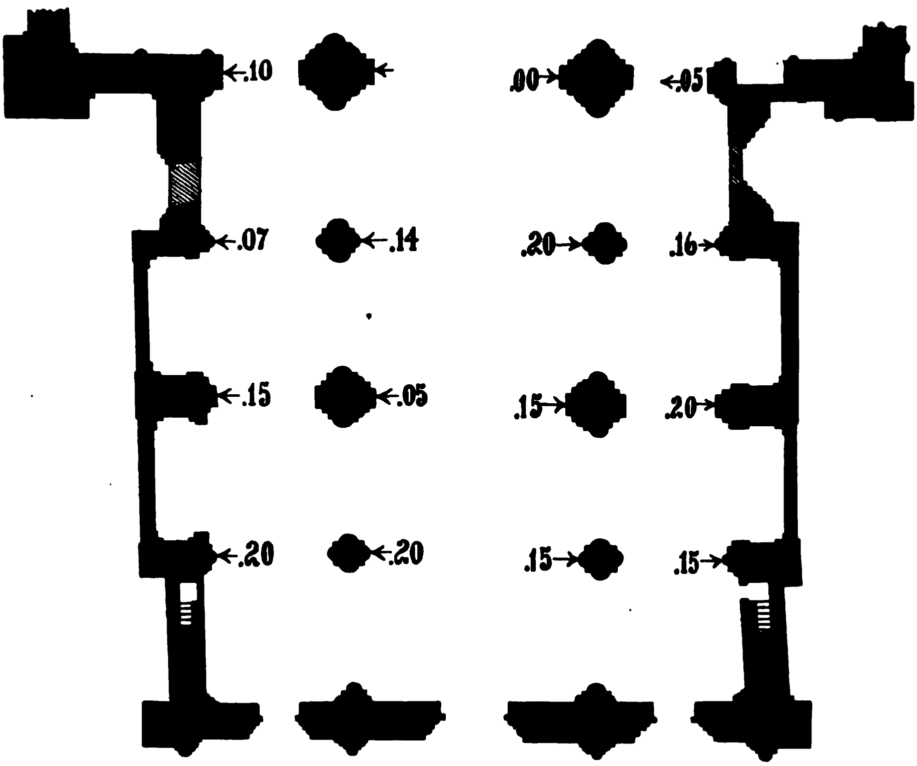
Sketch of the pier next the choir, on the right side of the nave.

In view of the satisfactory evidence for the side aisles it is hardly necessary to debate the constructive evidence for the nave.

S. Ambrogio, S. Maria della Pieve and the Cathedrals of Perugia and Trani are the only churches observed, in which the leans of the nave piers start from the pavement, with the full amount of the ultimate inclination. Whereas the piers at Arezzo have a delicate but sensible curve, those at Milan have absolutely none. At Prugia the side aisles are nearly as high as the nave and a vaulting thrust has certainly to be considered there as a possibility. On the other hand, when the weight of the galleries, the low side aisles and heavy aisle vaultings of S. Ambrogio are considered, the proposition that the nave vaulting could have pushed over the piers to the amount of 6 inches and in a straight line starting at the pavement, is too absurd even for mention.

In S. Michele at Pavia an aisle photograph was taken with plumb-line in position but was less successful than the pictures in the Milan churches. The facts are of the same nature as regards the aisles and are represented by Plan 2. The small amount of the leans is as notable as their uniformity (one exception.) With a line of 9 feet the minimum is ¾ of an inch, the maximum 2½ inches. The only plumbs for the nave are those taken with a short line of 9 feet in length, which was being used in the side aisles. The piers curve back above (as judged by the eye).

As judged by the eye, the first three pairs of piers are marked cases of curving outward, above; but the outer bend of the last pair of nave piers is slight, and no outward receding is perceptible in the arch of the apse. This absence of outward receding in the apse is exceptional, as contrasted with Vicenza, Arezzo, Milan, Bologna, Borgo San Donnino, St. Mark's and S. Giorgio Maggiore at Venice. In the Capella Palatina of Palermo, it is only in the arch of the apse at the choir that the refinement is found. It may be that repairs have obliterated the lines in S. Michele or that masons were employed, at some date, in the original building who were indifferent to this refinement.



PLAN 2. THE NAVE OF S. MICHELE, PAVIA.

The plumb measurements, in foot-decimals, were taken in the aisles with a line of 9 feet, reaching to the capitals of the pilasters. The same short line was used in the nave. Therefore, the measures for the nave do not represent the amount of widening. They only indicate the vertical direction for the given height.

S. Francesco at Pavia is a Gothic church with chapels opening on the side aisles like the churches just named. The walls of these chapels are 12 feet deep. The pilaster leans are well defined in these aisles and the outward spread appears in the nave. No measures or photographs have been taken here. The observations date from 1895 and the church was not examined in 1901.

Borgo San Donnino and Cremona.

The effort had been made in 1895 to examine all previously unvisited important churches of North Italy, between the dates of Oct. 5th, when survey work was finished at Pisa, and Oct. 17th, when passage had been engaged from Genoa for the United States. After depositing baggage and 550 photographic negatives at Genoa, the following towns were visited, between the 7th and the 17th, in the order named: Pavia, Milan, Piacenza, Cremona, Parma, Borgo San Donnino, Modena, Ravenna, Ancona, Rimini, Padua, Vicenza.

No more attention was paid at this time to the refinement discussed in this Memoir than to many others. The deficiencies of record at Pavia and Milan were made good in 1901, as just described, but Borgo San Donnino was not revisited.

In 1895, the custodian of the Cathedral of Borgo San Donnino allowed a survey of the pier spacings and height of arches to be made on a Sunday morning, during low mass, when the church was crowded with people. The custodian carried the pole with which the heights of the arches were taken and assisted with the tape in taking other measures. It was under such circumstances that a hasty sketch was made of a well-defined outward widening in the pilasters of the arch at the apse, where the absence of strong thrust, on the one hand, and the resistance to thrust, on the other hand, made out a thoroughly impregnable case of construction. An Alinari photograph, which has been recently procured of this church, verifies the sketch made at that time and also indicates that the same spread is found in the clerestory walls. The Alinari photographs of recent date have been found to be very reliable as regards the vertical lines.

During the same trip the Cathedral of Cremona was surveyed for the ground-plan and careful observations were made of a uniform outward receding of the clerestory. The photograph reproduced in Fig. 14 was subsequently made by a Cremona photographer, by direction of the writer, and forwarded to the United States. The photograph is out of perpendicular and the drawing from it (unlike the other drawings of this paper) is rectified. In spite of the unreliability of the photograph as an exact record, the essential facts are shown by the drawing.

Cremona Cathedral offers the only instance which has been noticed, of a defined inward lean below, which reverses to a strong outward bend above. By careful estimate, in sighting by the eye, the piers lean in about 6 inches on each side and the pilasters and clerestory walls lean outward about a foot on each side. The pointed arches of the vaulting are in perfect condition and are ab-

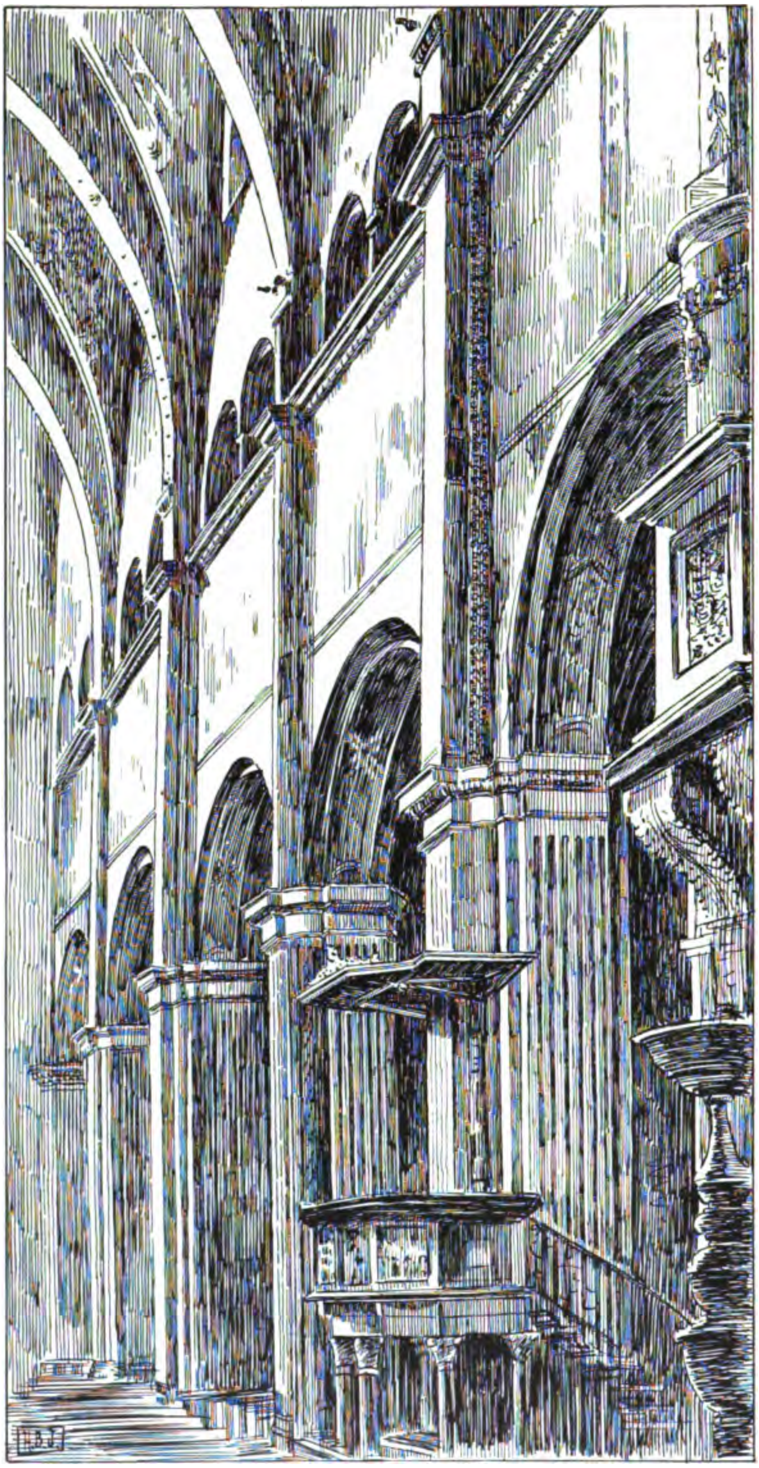


FIG. 14. THE CATHEDRAL, CREMONA.

View looking toward the façade on the left side of the nave. From a local photograph. The drawing is corrected for distortion. The piers lean into the nave, to the height of the capitals, and the pilasters recede outward above the capitals. The widening of the nave is estimated at 24 inches.

solutely without the depression which an accidental widening of two feet in the nave would have carried with it.

Cremona was revisited in 1901, especially in order to take the heights of all the arches, a very difficult task to accomplish with a pole, on account of their great height. The widening was again carefully examined, but a photograph which was made of the nave in parallel perspective proved to be a failure, when it was developed at Pavia. On account of the great size of this church and the difficulty of access to the clerestory openings, which are above the vaulting of the side aisles, it would be very difficult to take plumb measurements in this cathedral for the widening, but a good survey photograph would supply satisfactory means of measuring the exact amount.

The vertical bend at Cremona is not essentially different in principle from that in St. Mark's at Venice, although it is differently planned. This Cremona bend grades towards another type in which there is a curve or entasis in the nave pilasters without any marked recession. In the piers of the great arches which span the nave of the Pisa Cathedral, at the transept crossing, there is a well-defined vertical curve which leans out slightly into the nave and has a delicate return bend at the springing of the arch.* A certificate from the architect in charge of the Cathedral regarding this and other curves was published in No. 1 of these Memoirs.

A fine illustration of this delicate vertical curve is found in the Cathedral of Vicenza (Fig. 15), under circumstances which eliminate all possibility of explanation from accidental causes. As in the quoted churches at Pavia and Milan, the pilasters in the Vicenza Cathedral face chapel walls of great depth (25 feet) with the difference that these chapels open directly on the nave (Fig. 16).

These vertical curves were noticed on October 16th, 1895, the day before sailing from Genoa, and were photographed on Sept. 1st, 1901. Similar vertical curves have been noticed in other churches, but nowhere, outside of S. Paolo Ripa d'Arno at Pisa, where the conditions were so absolutely satisfactory for a demonstration of constructive existence. In S. Paolo Ripa d'Arno the vertical curves are found in flat pilasters which frame the arch of the apse and which are projecting members of a solid wall. These curves were measured and photographed in 1901. Enlargements of these photographs are exhibited in the Brooklyn Museum.

These instances at Vicenza and Pisa will undoubtedly react on the view which will ultimately be taken of similar vertical curves in other churches, but it is not advisable at present to quote doubtful cases. In all vaulted churches with side aisles which are lower than the nave, the aisle vaultings thrust in such

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*Architectural Record, Vol. VII., No. 1, p. 77.

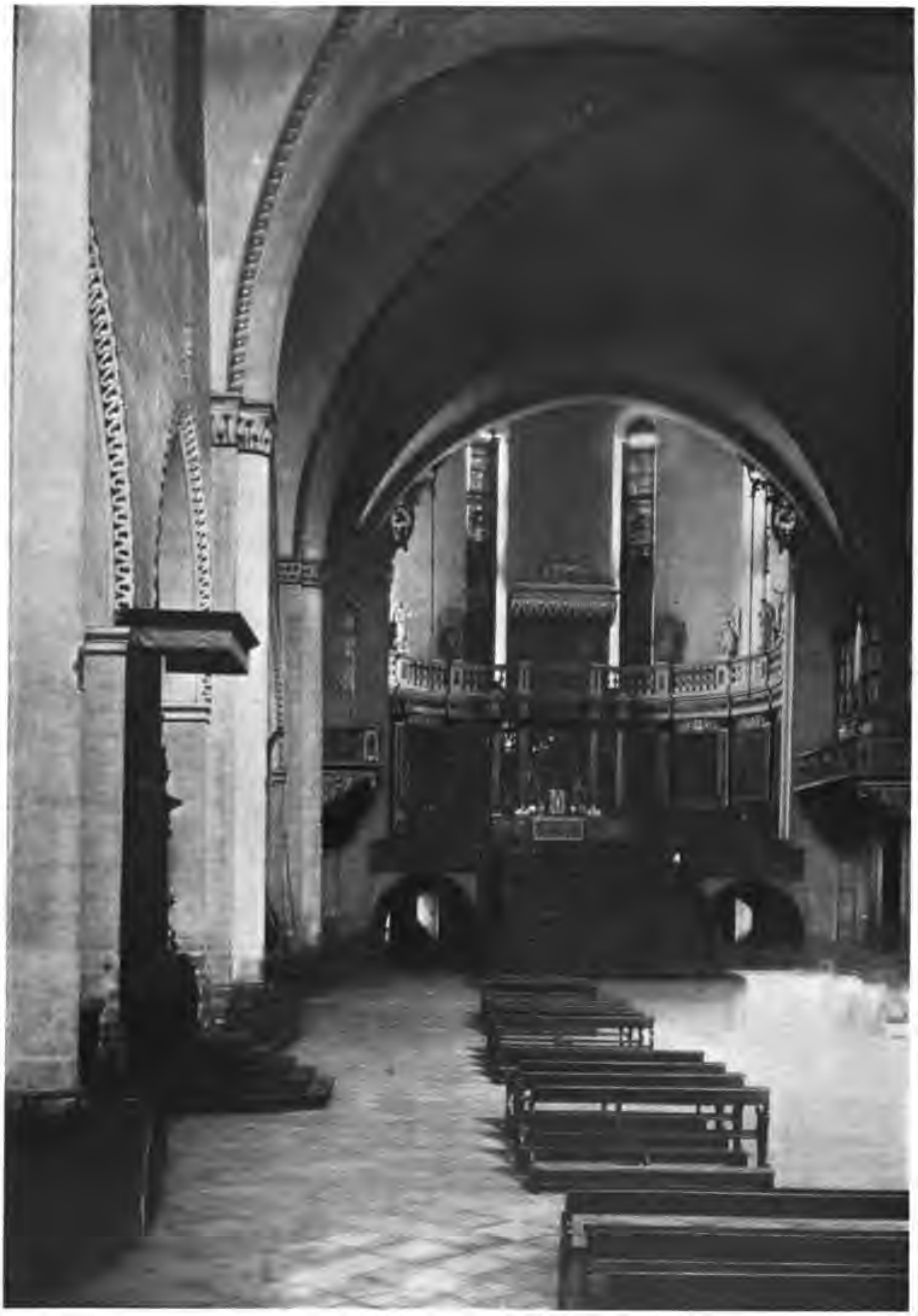

FIG. 15. THE CATHEDRAL, VICENZA.

From a Survey photograph of 1901. Showing delicate vertical curves in the piers. The conditions of thrust are shown by Fig. 16.

a way as to tend to produce this kind of a curve accidentally, and this tendency is accented by the upper thrust of the higher nave vaulting in the opposite direction. Under these circumstances two demonstrated cases like those of S. Paola Ripa d'Arno at Pisa and the Cathedral of Vicenza are worth more than hundreds of probabilities. Whatever may be found in the future it is impossible to suppose that these instances could be isolated and they prove the whole point at issue, viz., that mediæval architecture does exhibit very subtle refinements in vertical lines. The absence of aisle thrust at Vicenza is a notable and rare occurrence.

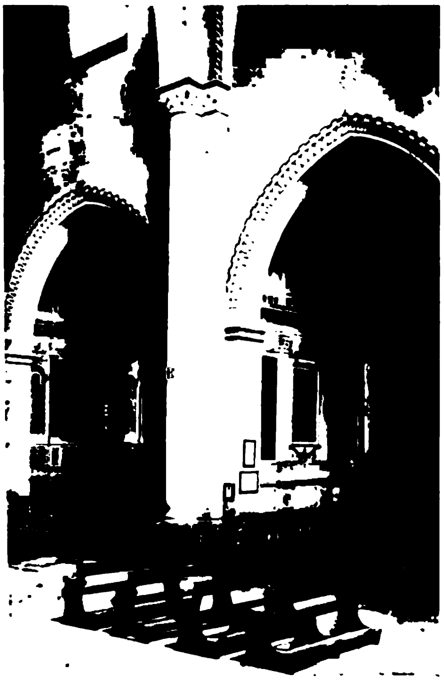

FIG. 16. THE CATHEDRAL, VICENZA. From a Survey photograph of 1901. Showing the depth of the chapel walls.

Although somewhat aside from the direct problem of this Memoir, all observations which demonstrate the existence of mediæval architectural refinements in the treatment of vertical lines have the greatest possible value for the ultimate comprehension of the system of verticals which diverge outward.

The Cathedral of Siena shows in the ruined and uncompleted part which was to have been the new nave, a very pronounced case of outward curving verticals in the piers. In three separate visits to Siena, twice in 1895 and once in 1901, I have studied these piers without being able to decide whether thrust had only accented, or whether it had wholly caused these bends. Any expert who examines them without knowing of other positively constructive instances will certainly decide that thrust is the only cause. I am not certain that it is, and should not like to affirm that it is not.

In order not to omit any known instance of the spread in Italy, reference is made here to the Cathedral of Aosta as made known to me by my friend, Hugh D. Rooper, Esq., Retired Commander, Royal Navy, of Richmond, Surrey, England. The date of the communication making this announcement is August 12th, 1902.

S. Giorgio Maggiore at Venice.

The evidence supplied by the mentioned churches at Orvieto, Vicenza, Pavia, and Milan, is so firm and definite that it has seemed possible to waive, in this Memoir, those details regarding the church

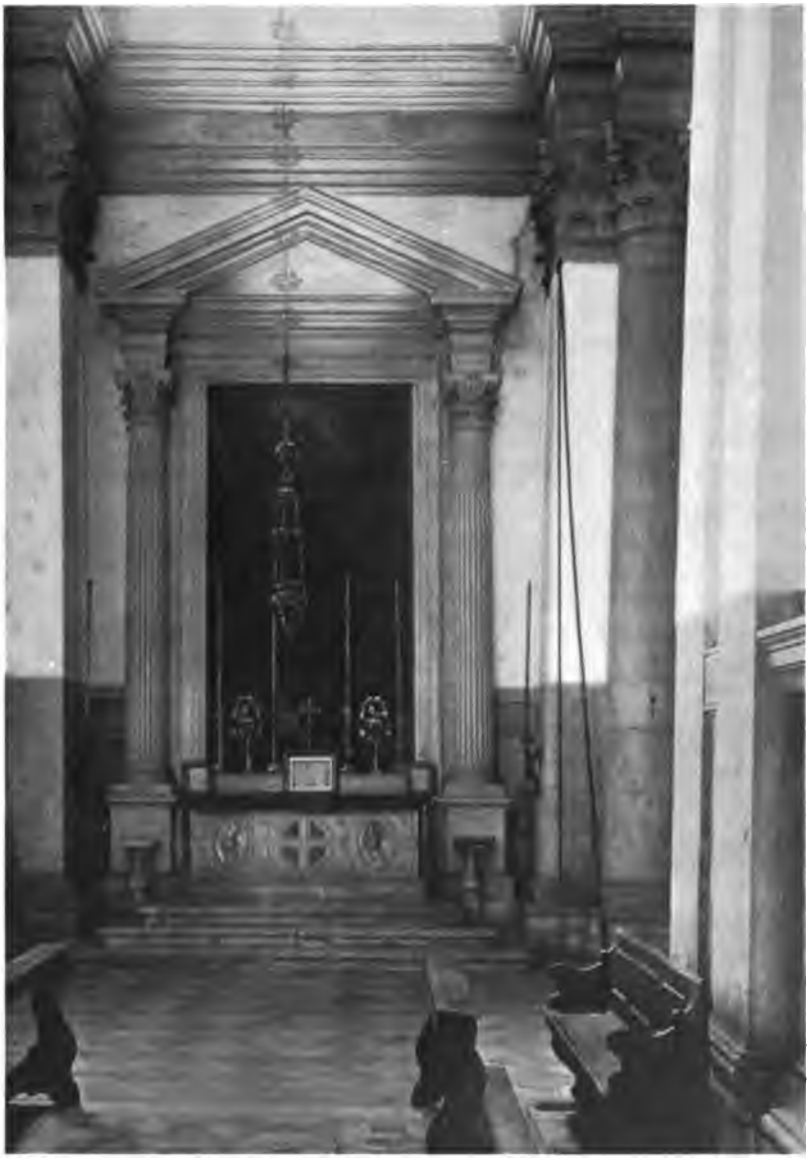

FIG. 17. S. GIORGIO MAGGIORE, VENICE.

From a Survey photograph of 1901. View looking across the façade wall toward the right aisle. The plumb-line, of broad black tape, is held in position by a pole. The pilaster leans 5½ inches in 20 feet.

of S. Maria della Pieve at Arezzo which have been previously published.* Before taking up the important case of St. Mark's at Venice, we have to record a remarkable survival of "outward receding" in the Renaissance church of S. Giorgio Maggiore at Venice, by Palladio. The facts were overlooked by all the members of our surveying party in 1895. They were noticed and photographed in 1901, on various dates between Aug. 16th and Aug. 30th, inclusive.

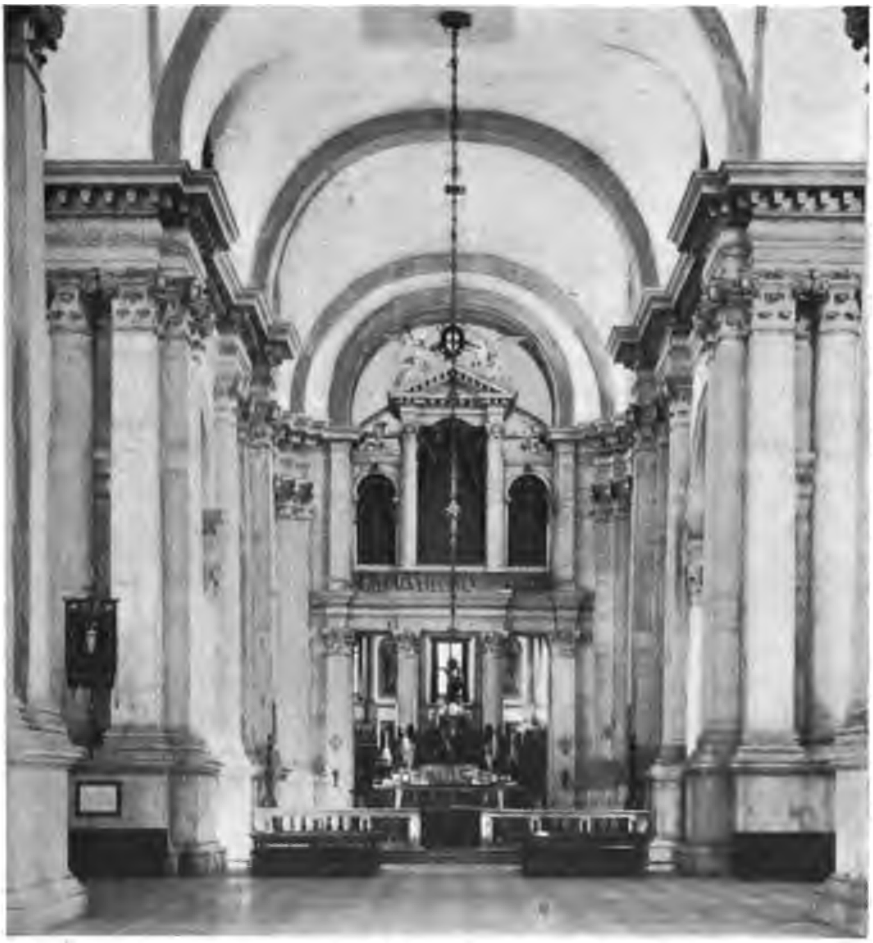

FIG. 18. S. GIORGIO MAGGIORE, VENICE.
The choir; from a Survey photograph of 1901. The widening is estimated at 10 inches.

Fig. 17 shows the first chapel is the right aisle, with a tape and plumb-bob hanging on the pilaster. This pilaster leans back 5½ inches in 20 feet, and the illustration is typical for the entire church.

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*Architectural Record, Vol. VII., No. 2, p. 211.

There is absolutely no thrust in question here, because the pilaster plumbed is part of the right side wall of the church. The view is taken looking along the façade wall of the church and the leaning pilaster on the right of the picture is part of this entrance wall. The purpose of the lean in Fig. 17, is obviously to work in a parallel to the outward receding of these great pilasters of the façade wall.

Fig. 19 shows the right aisle with a plumb-line on one of the pilasters. The lean is 5½ inches in 20 feet. The facts as represented in these pictures are uniform throughout the church.

Fig. 18 shows the widening in the choir of S. Giorgio Maggiore, which is also uniform throughout the nave. The outward lean at the choir is not less than 5 inches on each side, between the capitals and the pedestals, a distance of about 30 feet. The plumbs in the nave were taken under great difficulties, on account of the distance from the pavement to the capitals. The widening may be more than the 10 inches, at which the quoted plumbs would place it.

It is, of course, apparent in this church that the strong entasis and the strong related diminution of the classic pilasters, are made the means of obtaining the outward divergence. It is also apparent that the diminution, applied to flat pilasters, as we find it in the choir, or elsewhere, in this church, is wholly unprecedented and wholly inexplicable as a classic treatment. I have already pointed out in the Architectural Record; Vol. VII., No. 1, p. 92; that the entasis in the Teatro Olimpico at Vicenza, by Palladio, is applied to the flat surface of the pilasters in such a way as to produce the same vertical curve which is found in the Gothic Cathedral of Vicenza. This peculiarity is also found in Palladio's church of the Redentore at Venice. The Redentore has, however, no widening or outward receding. The same appearance, as regards use of the entasis (again without widening) is found in S. Stefano at Vicenza, by a pupil of Palladio.

The conceivable suggestion that the widening in S. Giorgio Maggiore is only the result of an exaggerated entasis is furthermore met by the observation that the leans are not found on those sides of the aisles which are adjacent to the nave, although the entasis is equally strong on both sides. This fact has been tested by plumbs in both aisles, and it corresponds to the facts which have been found in the mediæval churches as regards the aisles, viz., that the widening of the aisle is worked in wholly on the outer side. This will also appear in St. Mark's. Thus, in Fig. 19, if measurement be taken from the upper and lower ends of the plumb-line to the edge of the pilaster opposite, the distances will be found equal. The entasis is obviously as strong on one side as on the other; but on the left side of the aisle the pilaster is perpendicular, when its extremities are compared with the plumb-line. The same facts have been found to

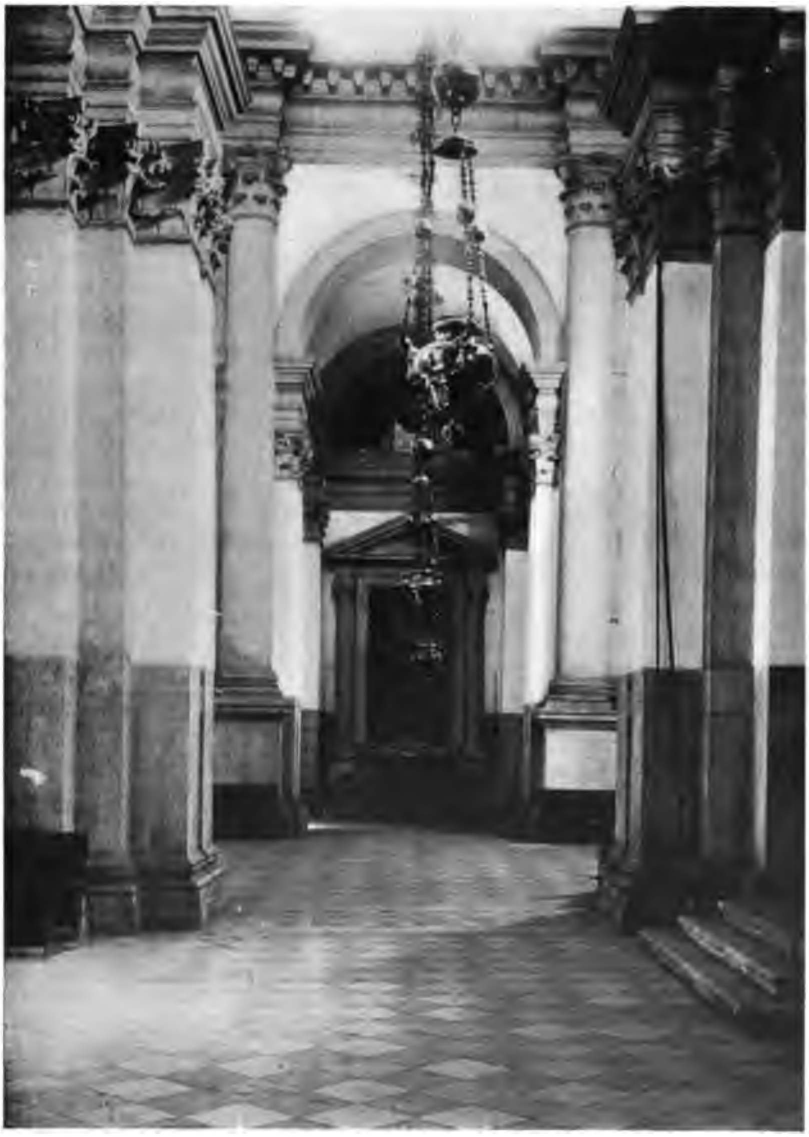

FIG. 19 S GIORGIO MAGGIORE, VENICE.

The right aisle; from a Survey photograph of 1901. The black tape plumb-line shows an outward lean of 5½ inches in 20 feet. There is a corresponding entasis on the left side of the aisle, but there is no lean on that side. Compare text.

occur in the other aisle. So in Fig. 17 the right pilaster leans back, but if measurement be made from the plumb-line at top and bottom, to the edge of the pilaster opposite, it will be found to be perpendicular; whereas the entasis is seen to be as strong on the one side as it is on the other.

St. Mark's at Venice.

It has been mentioned that the beginning of this special investigation, as distinct from the examination of other features of mediæval architectural refinements; which were generally first noticed in Pisa in 1870; was an observation in St. Mark's in that same year.

The examination of St. Mark's in 1895 was made as carefully as the six days' stay in Venice would permit. Subsequent study of the church has been much assisted by the survey photographs which were made at that time. These were taken with every precaution which photographic science could suggest, to ensure a record for future use, especially as regards the vertical lines. These records have been abundantly tested and verified bv the plumbs taken in 1901.

The main facts for the nave were shown in the publication of 1897, by one of these photographs and were shown still more visibly by a tracing from the same picture; Figs. 20, 21.

For the transepts, only tracings were published, as the original photographs were not suited for half-tone reproduction; Fig. 22.

As regards the main facts for the nave, they are now more adequately illustrated by three photographs (among others) which are reproduced in Figs. 23, 24, 25. These show the changes of direction in the rising line better than Fig. 20, which does not reach far enough down into the nave for that purpose.

In these pictures we are able to distinguish the nearly perpendicular piers, the outward inclination of the walls above the piers to the top of the parapet and the continued lean of less amount, and with a delicate return bend, up to the springing of the arches, The varying measurements for these various divisions of the vertical lines will be mentioned presently.

One main purpose of the Italian trip of 1901 was to bring the publication of 1897 to the attention of Commendatore Pietro Saccardo, the engineering architect in charge of St. Mark's, and to obtain a certificate verifying the facts which were published as being facts of original construction, as far as that church might be concerned. The circumstances under which this certificate was obtained were as follows.

My first call on Commendatore Saccardo was made at his resi-

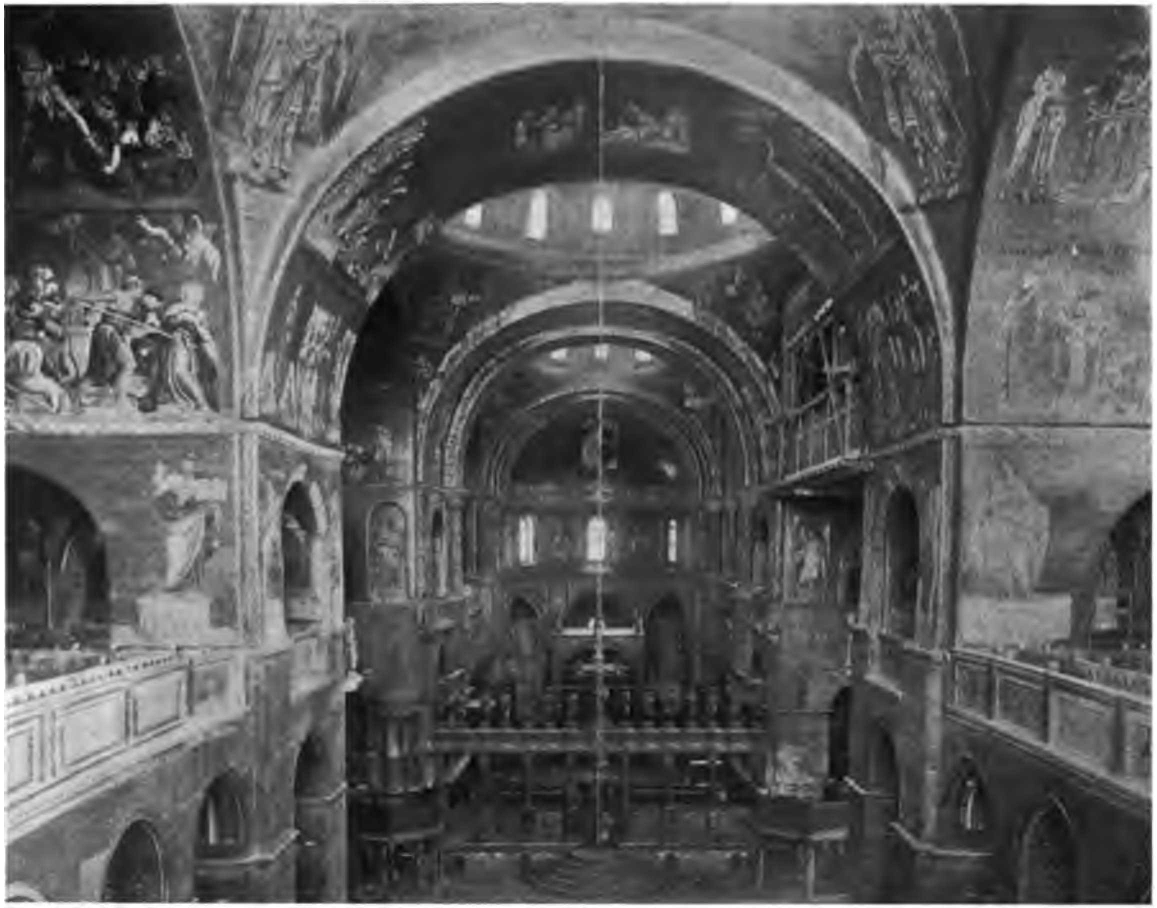

FIG. 20. ST. MARK'S, VENICE.
The nave, in parallel perspective; from a Survey photograph of 1895. The widening amounts to 2 feet, 10½ inches, at the transepts. Compare Fig. 21.

dence on August 16th. He was politely sceptical as to any constructive widening or spread in St. Mark's, but agreed to meet me at the church on the following day. We then met in the vestibule, where he drew my attention to a parting in the masonry over the main entrance, as indicating an accidental widening of the building. In reply to the question what the amount of the parting might be, he answered that it was about ten centimetres, or four inches. I then entered the church with him and drew his attention to a widening of nearly three feet in the nave (about 2 feet 10½ inches at the transepts) without parting and without flattening of the crown of the arches.

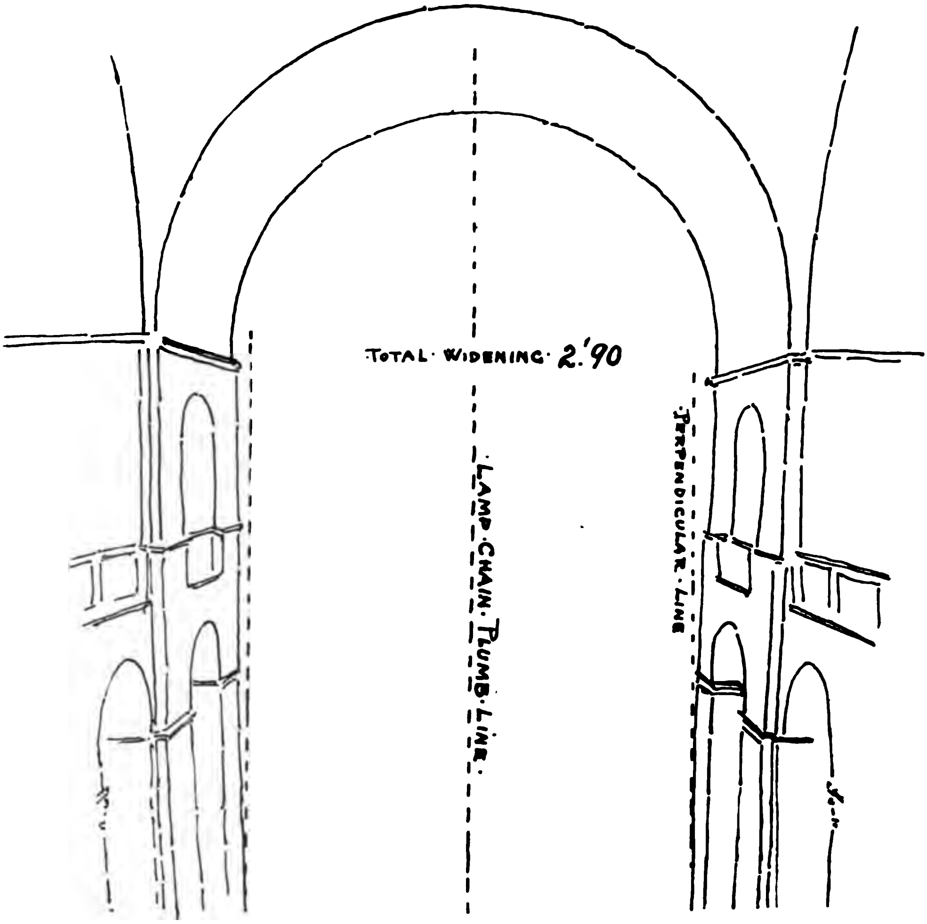

FIG. 21. WIDENING OF THE NAVE IN ST. MARK'S.
Tracing from the photographic original of Fig. 20.

Signor Saccardo thereupon agreed that no yielding of supports would account for such a widening in the upper portion of the church and that the arches and domes would have fallen, if the supports had gone apart accidentally to such an extent. He frankly admitted that he had not previously realized the full amounts of the outward leans, as these were made known to him through the published measurements of 1897, and by using the illustrations of the Architectural Record in face of the given portions of the church.

That the amount of these spreads has not been realized hitherto by other modern experts, has appeared by personal conversation with many of them. The reason for this oversight, as in the case of several similar oversights on the part of the members of our own survey, is, no doubt, that the leans are about sufficient to correct the perspective convergence in the vertical direction, so that the lines appear perpendicular to casual observation. It may be that this correction was one purpose of the widening. There is also a natural tendency to attribute any individual deviation from the perpendicular, which may be casually noticed, but not fully appreciated, as to amount, to accidental causes.

During the interview with Signor Saccardo, we spent much time in the galleries and among the facts which were pointed out to him were those regarding the terminal north and south walls (and parapets) of the transepts (Figs. 32, 33). These walls lean back about 16 inches (north) and about 15½ inches (south) up to, and including, the parapets, in a height of about 33 feet; while the adjacent arches are perfectly true in both transepts. The arches nearest these walls would have spread, or parted, over a foot, in a width of about eight feet, if yielding foundations had caused a movement of the building. This amounts to saying that the given arches would have collapsed. The leans of these walls were immediately conceded by Signor Saccardo to be constructive.

Signor Saccardo's attention was also drawn, in the galleries of the transepts, to the columns which lean back against the gallery piers, with capitals which are level or tilted downward and not tilted backward like the columns; Figs. 36, 37. He used the words "lavoro immenso," "osservazioni fine," as these facts were pointed out to him. Many remarkable corroborations of the general main facts were only subsequently ascertained and therefore could not be made known to Signor Saccardo at this interview.

Following our tour of the church he kindly undertook to ascertain the amount of the forward constructive lean of the Porta della Carta, which he had been the first to observe and which is mentioned in his letter. We plumbed this together.*

At the close of our interview, which occupied the entire morning, Signor Saccardo deputed Signor Agazzi, who is in charge of the mosaic repairs, to give me access to all parts of the church for

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*Memoirs, Vol. I., No 1 p. 19.

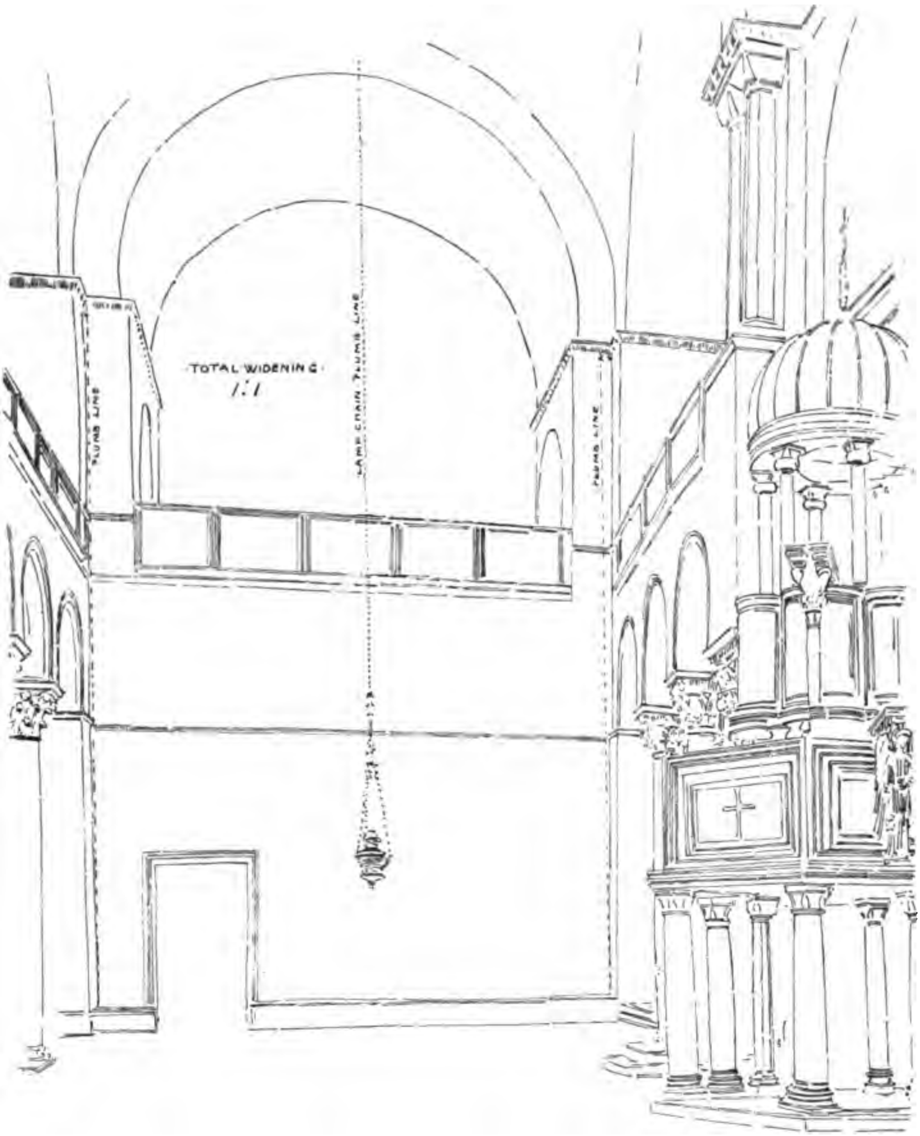

FIG. 22. NORTH TRANSEPT OF ST. MARK'S; FACING NORTH.

Tracing from a Survey photograph of 1895. The wall in face leans north, up to and including the parapet; 16 inches in about 33 feet. The pilasters of this wall face the north and south walls of the Chapel of St. Isidore. Compare Plan 3 and Fig. 31. The tracing shows the east and west leans of the transept, including those of the gallery columns on the east side. The measurement entered on the tracing is an approximate estimate, based on the known width of the transept. The south transept shows the same construction. Compare Figs. 36, 37, 38, for the south transept.

the taking of additional measures and photographs. Assistants were furnished, as needed for this work, from the employees of the Opera. I am also much indebted to Signor Agazzi for many courtesies and for his constant kind attentions, during the remainder of my stay in Venice.

The Certificate.

A few days after this interview the following letter came to hand, in answer to a request for an opinion on the widening of the nave, for an opinion on the outward leaning columns of the façade* and for an opinion on the horizontal curves in elevation of the gallery parapets.†

Signor Saccardo's qualifications as an expert on these points are undoubted. He has been for many years employed on the repairs of St. Mark's and has published a monograph on this subject. He has also been one of the collaborators on the text of the magnificent publication of St. Mark's by Ongania. His researches concerning the piling and foundations of the church have been republished by Boito, and by Mothes, in his history of mediæval architecture in Italy, which is considered the leading German authority on this subject. The diagram of the piling and foundations of St. Mark's which is published by Mothes, is credited to Saccardo.‡

BASILICA DI S. MARCO
IN VENEZIA.
DIREZIONE DEI RESTAURI
E DELLO STUDIO DI MOSAICO.

VENEZIA, 19 Agosto, 1901.

CHIARISSIMO SIGNORE:

Permettemi anzitutto che mi congratuli con Voi degli importanti studi che andate facendo da molti anni sopra i monumenti antichi e in ispecie intorno a certe particolarità di costruzione in gran parte sin qui ignorate e che rivelano sapienti e ingegnosi artifizi usati dagli architetti che li eressero, per ottenere effetti prospettivi singolari. Già si sapeva come, per esempio, ne' monumenti di architettura medioevale si avesse il costume d' inclinare all' infuori i frontoni e le cuspidi con gli ornamenti sovrapposti, come si fa anche in oggi per i quadri e per le statue. In particolare questo artifizio vedesi usato assai marcatamente nelle cuspidi della facciata principale della nostra Bascilica di San Marco; non così in quelle delle facciate laterali, perchè l' architetto che le ricostruì, nei restauri di circa trenta anni or sono, non capì il magisterò che aveva presieduto al loro collocamento e le mise a piombo. Lo stesso artifizio vedesi usato nella Porta della Carta del Palazzo Ducale e in tanti altri monumenti anche fuori di Venezia, come per esempio nel Sepolcro degli Scaligeri a Verona. Si sa del pari che nella stessa

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*Memoirs, Vol. 1., No. 1, p. 19.

†Architectural Record, Vol. VI., No. 4, p. 503, 1897.

‡Mothes; Die Baukunst des Mittelalters in Italien. Fig. 209, p. 794, Vol. II., showing the foundations of St. Mark's, is borrowed from the work of Boito, and so credited. On p. 798 mention is made of the fact that Boito had republished the investigations and drawing of Saccardo.

nostra Basilica la facciata principale è disposta in curva sensibilmente rientrante.

Così i sei minareti della stessa facciata non sono eguali in altezza, ma vanno salendo da una parte e dall' altra verso la cuspide centrale. Che si fa eccezione quello dell' angolo sud-ovest, egli è perchè fu rifatto in seguito ad un incendio e chi lo rifece non s' accorse dell' artifizio e lo costrusse eguale al penultimo.

Voi poi trovaste nuove particolarità di questo genere che io aveva sempre creduto accidentali, ma che essendo comuni a tanti altri monumenti devono accettarsi quali veri artifizi di costruzione. Tali sono le colonne della facciata della nostra Basilica sensibilmente pendenti all' infuori nell' ordine inferiore e a piombo nel superiore. Tali sono pure i piedritti interni sostinenti le volte maggiori che l' inclinano all' indentro, aumentando così notevolmente la corda dell' arco che si corrisponde, in confronto della base, senza che l' arco presenti qualsiasi abbassamento o deformazione; il che dimostrerebbe che cosi fossero stati disposti fino dall' origine. Tali sono finalmente i parapetti delle gallerie, composti a plutei, che vanno da un arcata all, altra lungo le braccia della crociera, i quali sono marcatamente curvilinee con la convessità all' insù. Bisogna certo ammettere che specialmente in quest' ultimo esempio qualche deformazione possa essere stata causata, o per lo meno aumentata, dallo squilibrio dei pesi delle masse murali sopra un terreno cedevole come quello di Venezia. Tuttavia il caso è troppo costante perchè si possa ammetterlo siccome puramente accidentale in via assoluta.

Del resto gli studi che voi andate facendo sono molto interessanti e possono condurre anche ad altre scoperte più importanti ancora; per cui sono a congratularmene e in pari tempo vi prego di credermi quale ho l' onore di professarmi.

Vostro dev. servo,

PIETRO SACCARDO.

Sig. Wm. H. Goodyear, Curatore delle Belle Arti
nel Museo di Brooklyn a Nuova York.

TRANSLATION.

Basilica of S. Marco in Venice.
Direction of Repairs and of the Studio of Mosaics.

Venice, August 19th, 1901.

Very Dear Sir:

Allow me first of all to congratulate you on the important studies which you have made for many years of the ancient monuments and especially regarding certain particulars of construction which hitherto have been generally overlooked and which reveal ingenious and scientific artifices, on the part of the architects who built them, for obtaining special optical effects. It has been already known how, for example, it was customary in mediæval architecture to incline forward the gables and pinnacles, as is still done for pictures and statues. This artifice is particularly apparent in the pinnacles of the principal façade of our Basilica of San Marco, but not so in those on the lateral façades, because the architect who restored them some thirty years ago did not comprehend the art

which had directed their original collocation, and therefore he set them upright. The same artifice [of forward leaning] is visible in the Porta della Carta of the Doge's Palace and in many other monuments even outside of Venice; as, for example, in the Tombs of the Scaligers at Verona. It is likewise known that the principal façade of our Basilica is constructed with an inward curve in plan.[*] The six pinnacles of the same façade are likewise of unequal height and so arranged that they rise toward the centre. If the one at the southwest angle makes an exception, that is because it was restored after a fire by one who did not perceive the artifice and who made it equal to the last but one.

You, however, have found new features of this kind which I had always supposed to be accidental, but which, being common to so many other monuments, must be accepted as true artifices of construction.

Such are the forward leans of the columns of the lower order of our Basilica façade, whereas those over them are perpendicular.[†]

Such are the interior piers supporting the larger domes, which lean inward,[‡] thus considerably increasing the cord of the arch, as compared with the distance between the bases [of the piers] without any settlement or distortion of the arch; which proves that they had been originally built in this manner.

Such are, finally, the parapets of the galleries which connect the arcades of the transepts and which are distinctly curved in elevation and with a rising convexity. It must certainly be admitted in this last instance that some distortion may have been caused, or at least augmented, by the pressure of the masonry masses on the yielding soil of Venice. However, the occurrence is too uniform to be considered as purely accidental.

For the rest, your studies are most interesting and may lead to other discoveries still more important; for which you are to be congratulated, and I beg you to believe me

Your most humble servant,

PIETRO SACCARDO.

[Engineering Architect in charge of St. Mark's at Venice.]

The Plumbing of St. Mark's.

Nothing had been done in 1895 in the way of plumbing the church in detail, on account of the limited stay in Venice. In that year the effort to examine every important mediæval church and cathedral in Italy and the study of many distinct phases of architectural refinements, had involved a close economy of time as regards individual churches.

The work was now undertaken of ascertaining the general direction of the vertical surfaces and supports of the church, as far as this could be done with a pole and plumb-line from the pavement and by taking plumbs from the galleries. For the walls of the side aisles scaffolds or other special arrangements, involving time and expense, would have been necessary, and definite measurements cannot be quoted at present in the aisles, above the height which is accessible from the pavement.

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[*] Architectural Record, Vol. VI., No. 4, 1897, p. 489, and Fig. 44 of this Memoir.

[†] See Memoirs of Art and Archæology, Vol. I., No. 1, pp. 19-22.

[‡] *i. e.*, In the downward direction.

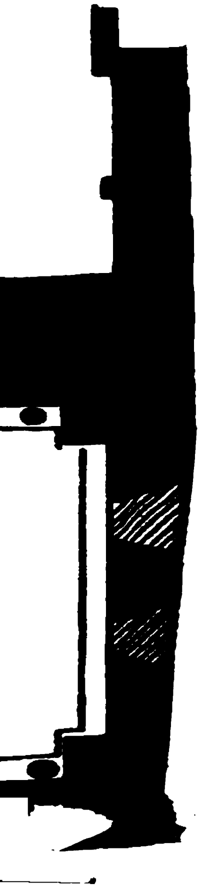
The work was tentative, hastily carried out, and subject to revision, as regards close accuracy; mainly on account of varying lengths of the plumb-line, when obstructions in the way of pulpits, benches, confessional boxes and steps were encountered. Allowances have also to be made for the fact that a plumb-line of 17½ feet was used in the nave, while a line of 15 feet was used in the transepts. Thus the pole measurements in the transepts are slightly under-stated, as compared with those in the nave and in the aisles of the nave. The measurements for the leans of the piers are also slightly under-stated if their whole height be considered, because they are surrounded by settees which prevent dropping a line to the pavement.

The plans which are published for these plumbs are not final, or perfect, as regards details, but they show the necessity for more thorough and more carefully executed surveys. They reveal a very remarkable series of facts as regards the system of vertical widening, in all parts of the building, and as regards the uniformity of direction and relative equality of the vertical leans, at distant but corresponding points. An astonishing series of incidental corroborations has been brought to light for the general main facts, as already published for the nave.

Measurements have been made by the plumb-line at a multitude of points, where even the suggestion of accidental movement is impossible. The correspondences in results at remote, but corresponding, points, render the theory of careless construction in the verticals equally impossible.

In spite of the free-hand irregularities of construction in this church, where errors of several inches and irregularities of marked amount can, in many cases, certainly be nothing more than bold and frank indifference to closely accurate work, it can now be proven that refinements of leaning verticals were planned, in which one-tenth of a foot in twelve feet was the amount of variation deliberately sought in some cases. This appears, for instance, from the measurements for the widening in the north vestibule; Plan 14,p.96.

The quotation of the measures in decimals of hundredths of a foot has, however, no general significance and must not be supposed to argue any effort on the part of the builders at closely accurate results in every given case, or in all corresponding cases. The measures themselves prove the contrary, by their correspondences in direction, on the one hand, as compared with their variations in detail on the other. The measures are quoted in decimals,



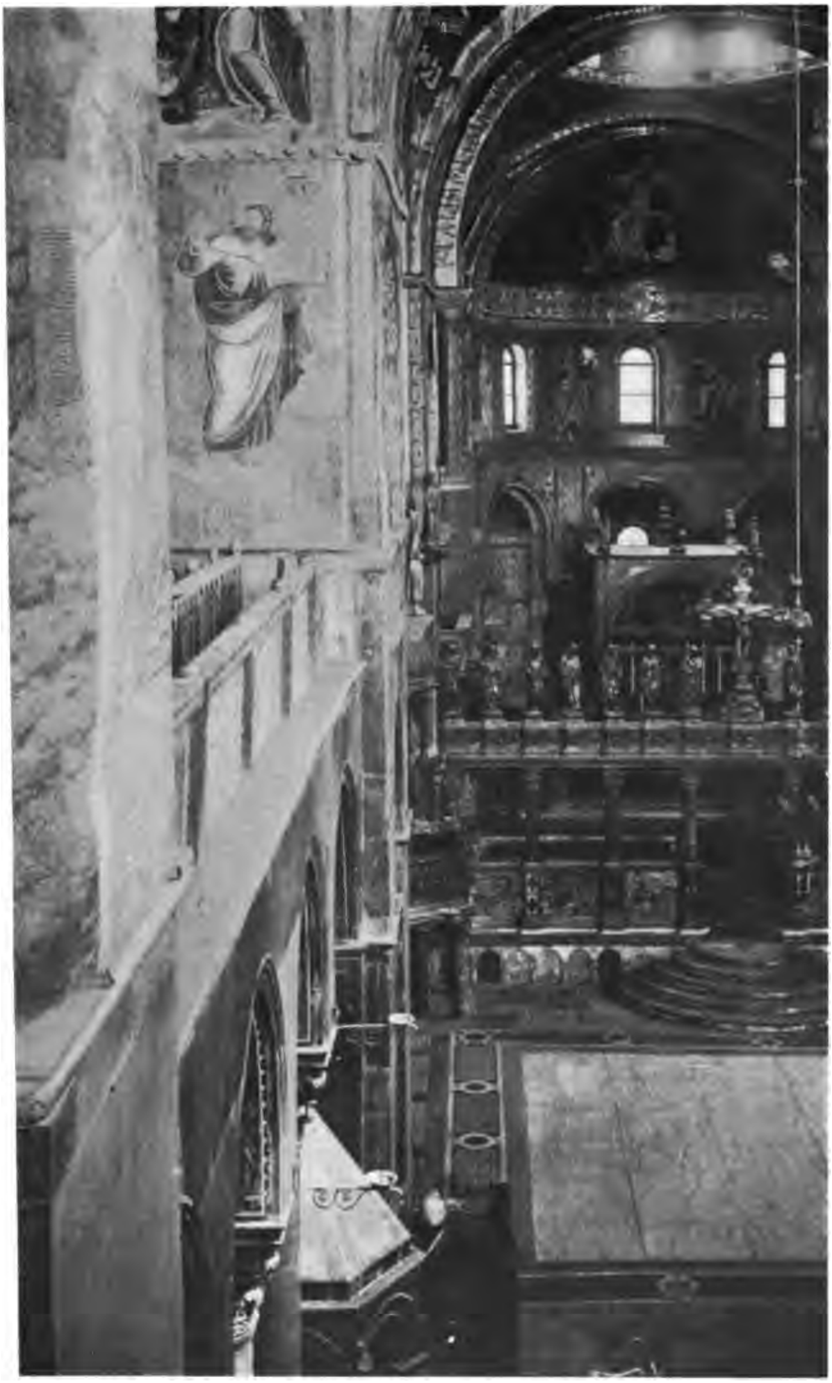


FIG. 23. NORTH SIDE OF THE NAVE OF ST. MARK'S.

From a Survey photograph of 1901. As compared with Fig. 20 (which shows the widening, but does not include the bend), this view shows the outward bend, contrasted with the nearly perpendicular lower piers in the nave. The lamp chain furnishes a plumb-line. For plumb measurements compare p. 65. The curve in elevation of the gallery string-course and parapet is also shown. Compare Fig. 42 for the north gallery curve.

because they are so found in the note-books of record and they are generally mentioned without reduction to the more easily grasped statement in inches, in order that they may appear as taken.

The general reasons for taking measures in foot hundredths are well known to surveyors. These reasons do not at all imply that the odd hundredths are uniformly important. The reason is simply that measures cannot be quoted, or taken down, in uniform style, when sixteenths, eighths, or quarters of an inch have to be mentioned. For rapid work, and rapid uniform entry, a tape marked off in feet, tenths and hundredths, is much the most convenient. How much importance is to be attached to the odd hundredths in subsequent reading of the measures is quite another matter and a careful examination of this question has also been made (p. 97).

The quotations will begin with the main general facts for the nave.

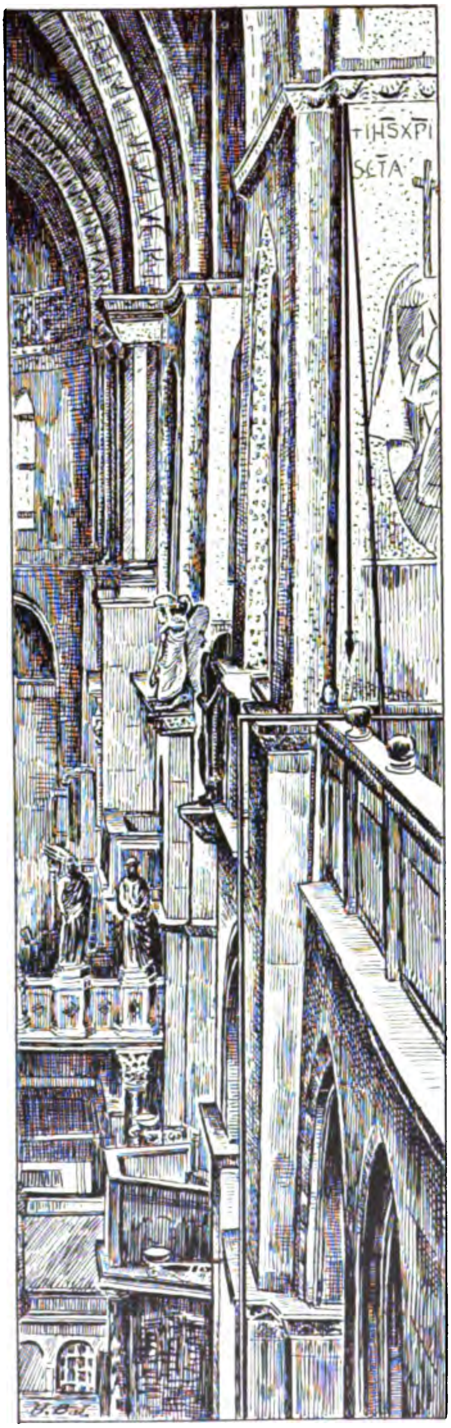


FIG. 24. SOUTH SIDE OF THE NAVE OF ST. MARK'S.
Tracing from a Survey enlargement of 1901.

The Nave of St. Mark's.

The estimate of the survey of 1895 for the widening of the nave at a given point (Fig. 21) was based on a photograph (Fig. 20) so taken in parallel perspective and so carefully levelled for the true perpendicular that the amount of widening might be estimated from the known width of the nave at the pavement.

This estimate is now supplemented and corroborated by plumbs taken in detail on each side of the nave, for the three separate divisions in its height up to the springing of the arches; viz., the piers from the pavement up to the moulding or capital, the pilaster casing or wall from the capitals of the piers to the string-course which corresponds to the top of the parapet, and the mosaic wall, from this string-course up to the springing of the arch (Figs. 23, 24, 25). Pole measurements cannot be taken in the gallery on this upper face of the wall at the points indicated by the estimate of Fig. 21. All three sections were therefore plumbed on the sides of the piers which are nearest the spectator in Figs. 23, 24, 25.

The measures of the leaning verticals for these various divisions are given below so that they may be read from the pavement up, or from the mosaic wall downward, as follows:

From the top of the parapet to the springing of the arch; about 13 feet.

Left; 3¾ inches. Right; 5 inches.

From the capital moulding to the parapet string-course; about 12 feet.

Left; 8 inches. Right; 8¾ inches.*

From the settees on the pavement to the capital moulding of the piers; about 18 feet.

Left; 1½ inches. Right; ½ inch.

Total: Left; 13¼ inches. Right; 14¼ inches.

On the right side of the church, however, the two upper faces step back. At the capital of the pier the right pilaster steps back about 2 inches (Fig. 24). This is included in the plumb from the parapet; but the stepping back of the mosaic wall at the parapet amounts to about 2½ inches. This lies between the plumb taken upward and the plumb taken downward, and must be added to the total widening, which thus amounts to about 30 inches for the given sectional plane.

This result corresponds very closely with the estimate obtained from the survey photograph of 1895; allowing for the fact that the lower piers, at the point there considered, lean off more than those just quoted.

They lean off; right, .17, as against .05 (Plan 4, p. 68).

They lean off; left, .30, as against .15 (Plan 5, p. 76).

This gives an extra widening of .27 or 3¼ inches, for the lower piers, which brings the sum total up to about 33¼ inches, without knowledge of what the variations may be for the two upper divisions, at the point where the survey photograph of 1895 gives a total of 2.90 or about 34½ inches.

An appearance in the church of having gone over to the right is produced by the leaning verticals of the right pier at the choir (Fig. 39). These are shown by the survey photographs to be more inclined on the right than on the left and they are easily to be noted

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*This measurement on the right side of the church includes a stepping back of 2 inches, so that the actual lean is about 6¾ inches. The stepping back of faces is mentioned in the text which follows.

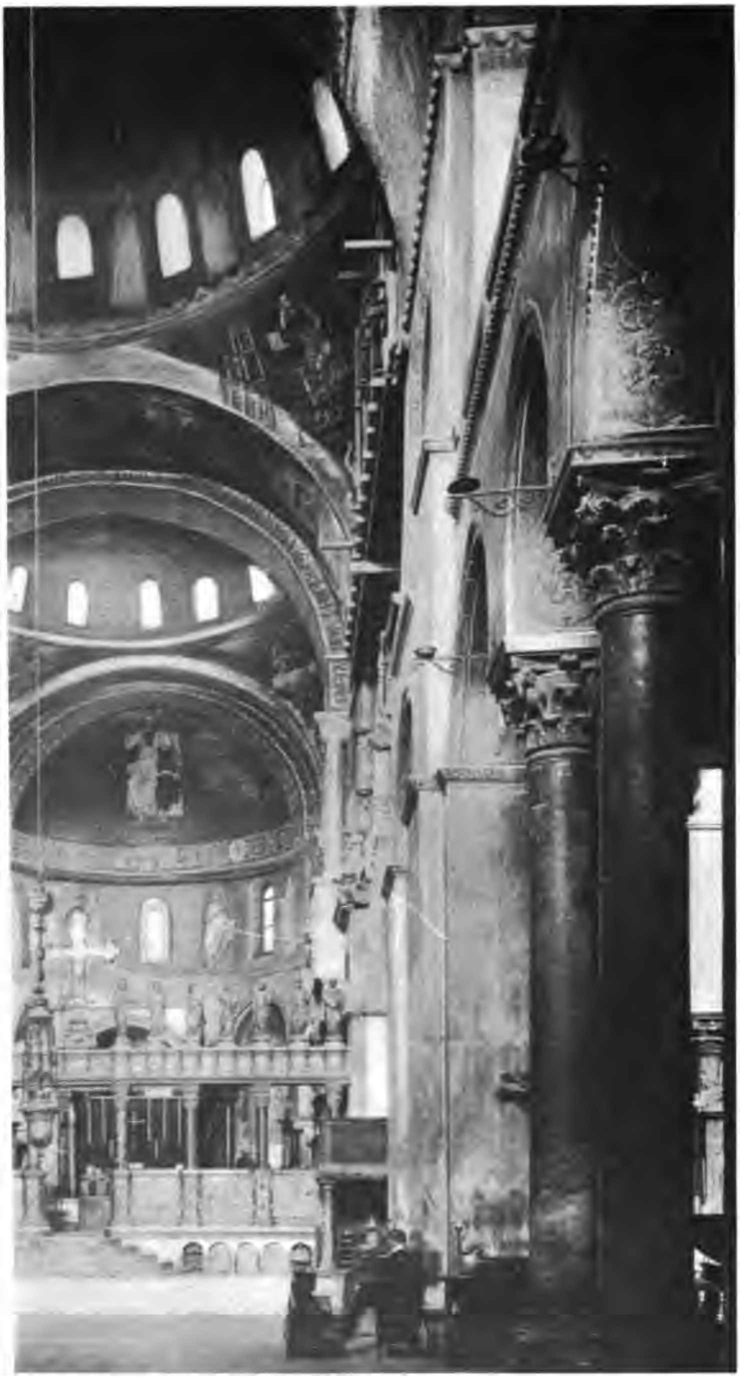


FIG. 25. SOUTH SIDE OF THE NAVE OF ST. MARK'S.

View from the pavement; from a Survey photograph of 1895. As compared with Fig. 20, which does not include the vertical bend, this view shows the nearly perpendicular lower piers, as contrasted with the change in vertical direction above their capitals. It also shows the delicate return curve of the mosaic wall, below the arch. The lamp chain furnishes a plumb-line. For plumb measurements compare p. 65.

in Fig. 39, as constructive. Measurements at this point by plumb, are obstructed below by the pulpit and cannot be taken at all from the galleries. The appearance in the church of having gone over to the right is also accented by the stepping back of faces, as already mentioned. Fig. 24, showing plumb-lines in position, is drawn from a tracing over a Museum enlargement, from the photographic series of 1901.

Distribution of Widening in the Nave as Regards the Various Divisions of Its Height.

It has just been observed that there are three separate divisions in the sides of the nave up to the springing of the arches. The amount of inclination in these various divisions appears from the quoted measures (p. 65) to be the greatest in the shortest division of all, i. e., the central division. For instance, on the left side of the nave the central division leans 8 inches in about 12 feet, whereas the pier below leans 1½ inches in about 18 feet, and the wall above leans 3¾ inches in about 13 feet. It may also be observed that the comparisons of amount for each section tally very closely on the two sides of the nave.

The sudden change in the amount of the leans above the capitals of the piers, which is indicated by these measures, is easily perceived in the photographs and in the building. At least, it is easily perceived after it is known to exist. Fig. 25 shows it with special clearness.

This sudden increase of inclination at the given point, which is found to be a uniform and constant fact in all portions of the nave, is a complete and decisive proof that no accidental movement has pushed these verticals out of plumb. No expert, who may have his attention called to this feature of the church in the building itself, will hesitate for an instant as to his verdict regarding construction.

The conditions of resistance and support for this central vertical division of the nave, which is found to have the greatest inclination, are shown by the aisle views (Figs. 26, 30). Plan 3 (p. 62) will show that the detail measures for the nave were taken at a point where the whole length of each solid transept wall has to be reckoned with, in the matter of accidental lateral movement.

The Aisles and Walls of St. Mark's.

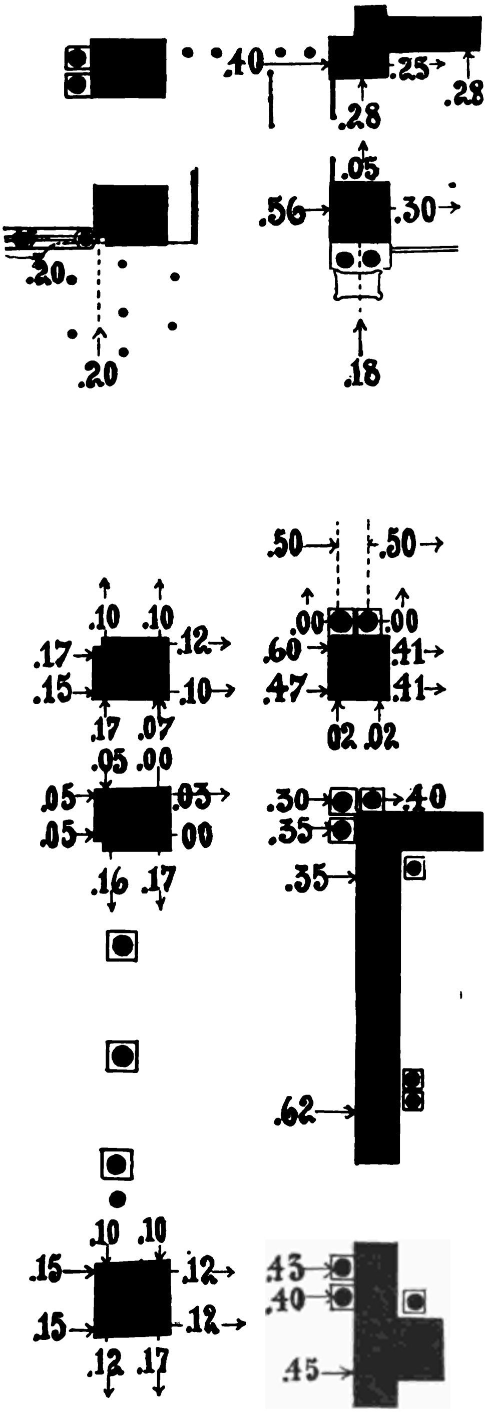
So far, the quoted measures have only supplemented in detail an observation for the nave which has already been published, which had already appeared to be of an impregnable character, and which has been verified as constructive by the engineering expert who was in charge of the church at the time of my most recent visit to Venice.

As regards the matter which follows, for the aisles and walls, the measures were not only taken after the interview with Signor Saccardo, but the results obtained were not anticipated. It seemed advisable, before leaving Venice, to plumb the church in detail, as far as it could be done rapidly and this was undertaken as a matter of record, but as a record which was not expected to supply any especially novel facts. Consequently the measures were not collated at the time when they were taken.

The mere entry of them on a ground-plan, which is the essential preliminary to any comparison of results, could not be undertaken, owing to the pressure of other occupations, until September, 1902. This will explain some deficiencies of the record. Its value lies in the suggestion that the work of a professional surveyor has been made necessary by its results.

As regards the plumbs for the piers, the capitals could be reached with a pole, by standing on the settees, and no particular apologies are necessary regarding these measures. As regards the walls, the measures have the value of bearing a definite relation to those of the piers, because they were taken with a line of the same length on the walls of the nave (17½ feet). This is really a material point, but the question as to the whole amount of the wall leans has still to be answered.

This uncertainty is connected with the peculiar construction of the galleries of the church, which, aside from the ends of the transepts, are narrow passages standing free from the side walls, which therefore rise to the whole height of the building. There are, how-



PLAN 4. RIGHT AISLE OF ST. MARK'S.

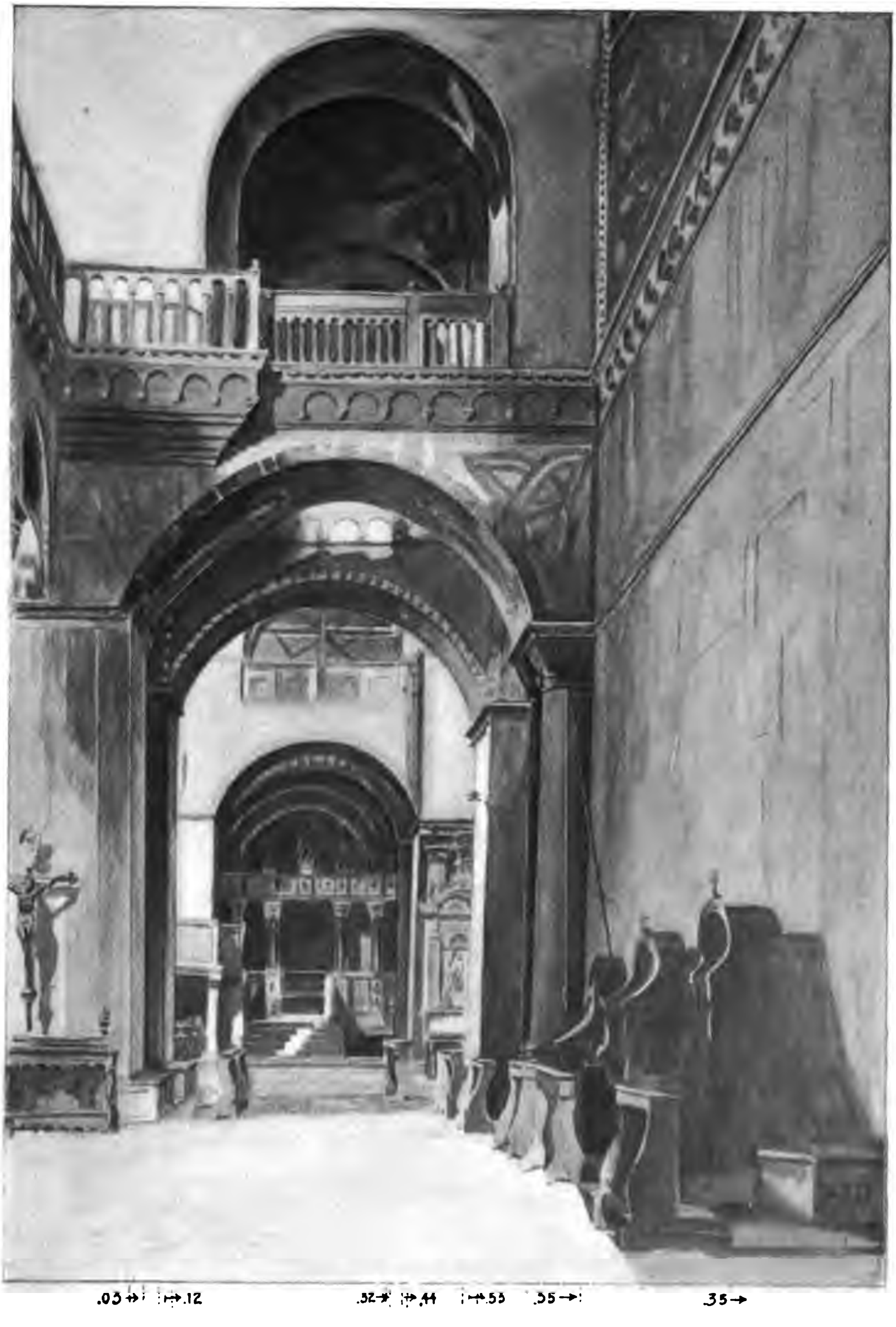


FIG. 26. THE RIGHT AISLE OF ST. MARK'S.

Accurate wash drawing, from a Survey enlargement of 1901. Showing a plumb-line on the engaged column. The plumb measurements entered beneath the drawing are found on Plan 4. As contrasted with the double measurement for each pier in Plan 4, only one plumb is entered for each pier. This view has the importance of showing the upper wall of the aisle. The enlargement indicates no change in the vertical direction of the wall until the mosaic surface is reached.

ever, several survey photographs which indicate continuous leans in these walls, up to the beginning of the mosaic wall (i. e. up to the height of the galleries), and these pictures were very carefully taken for future reference in the matter of the vertical lines. The enlargements which are exhibited in the Brooklyn Institute Museum have great value in this matter and the true perpendiculars are established for two of them with absolute certainty (Figs. 26, 30).

It is with reference to the aisles that we now again draw attention to the fact that a very insignificant amount of the widening in the nave is obtained in the piers, between the pavement and the capital moulding. For the first three piers of the nave, on each side, the amount of leaning on the side of the aisles is as follows, in the direction from façade to transept:

Right: .12, .12; .00, .03; .10, .12 (Plan 4).*
Left: .20, .20; .06, .12; .24, .20 (Plan 5).

Whereas some of these amounts are insignificant, and would hardly be considered, were it not for the proven intention of the widening higher up in the nave, it will appear that the engaged columns of the aisle walls lean outward in much greater degree (Plans 4, 5). These engaged columns of the aisles determine the dominant vertical effect of the walls, on account of their strong projection and massive size (Figs. 26, 30). The piers which continue the lines of the aisles across the transepts are also so placed as to line with these columns, as distinguished from the walls of the nave, and the pilasters of the transept walls at the entrances to the aisles of the choir are again placed in the same line with these engaged columns, as distinguished from the walls of the nave. Thus the vertical effects of the aisles are determined by the columns and by the piers and pilasters which are lined with them.

We will now consider that portion of the entire plan of the plumbs which is limited to the right aisle; Plan 4.

Among the remarkable facts disclosed by this plan, we note the uniformly higher average of the wall and column leans as against those of the piers of the nave. The maximum lean of the nave piers on the right side, is .12, or 1½ inches. The maximum lean of the engaged columns is .43 or 5¼ inches, and the minimum is .35, (Fig. 26.)

We next remark the arrangement by which the piers in the transept are leaned off so as to maintain a parallel direction with the verticals of the engaged columns of the aisle (Figs. 27 and 29).

We next notice the continuation of this parallel outward slope

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*As each pier was plumbed twice on each side, at the points marked by darts, the measures are quoted as taken.

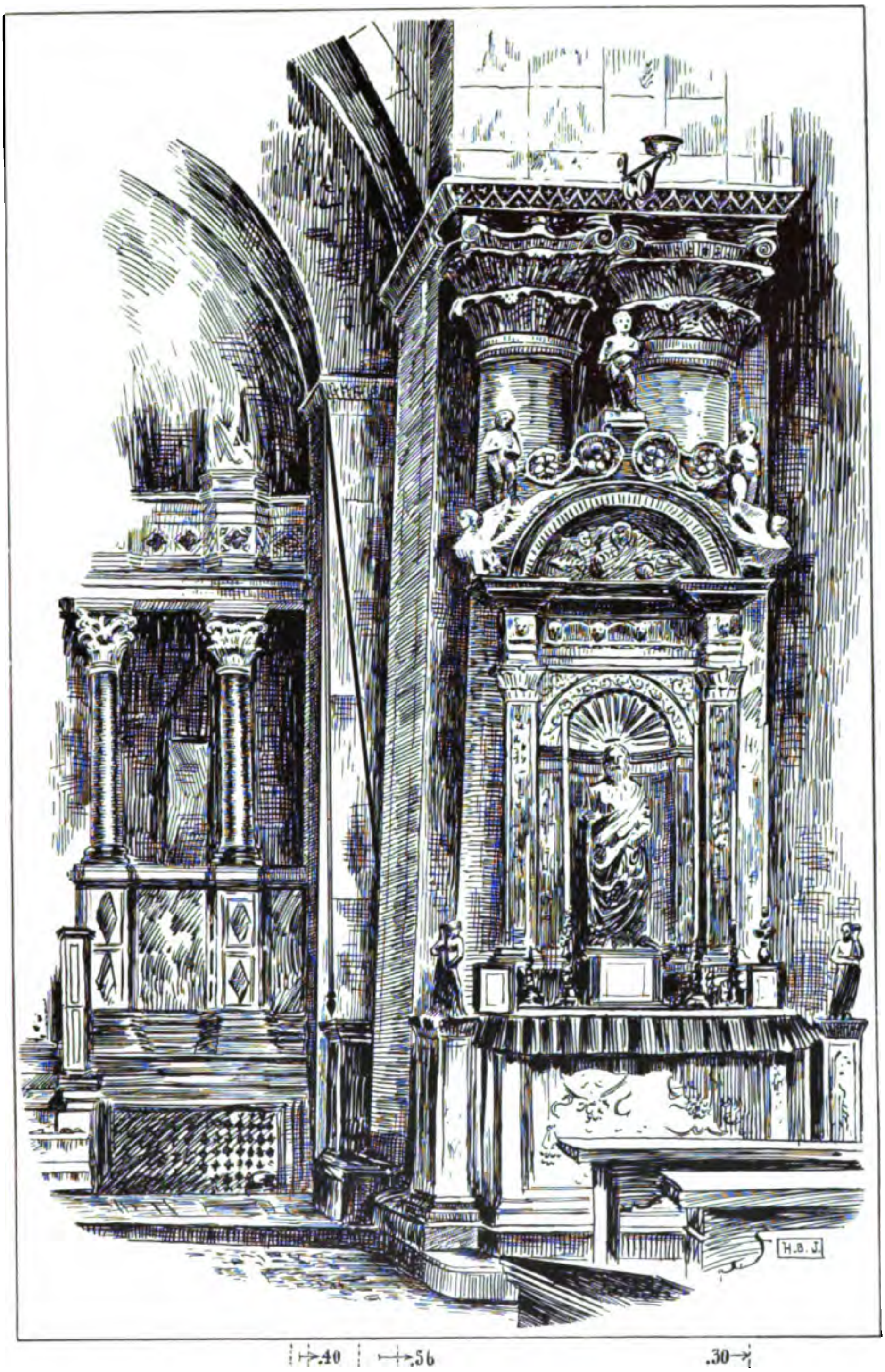


FIG. 27. RIGHT AISLE OF ST. MARK'S, AT THE CHOIR.

Accurate drawing from a Survey enlargement of 1901. The photograph includes a plumb-line. The pier in the foreground is also seen in Fig. 26. The plumb measurements are taken from Plan 4, and allowance has been made in the entry of .40 for the entire height of the pier. The pier in the foreground faces the pier in Fig. 29. For the contrast in measures between the two sides of the pier in the foreground (.56 and .30) compare text, p. 77.

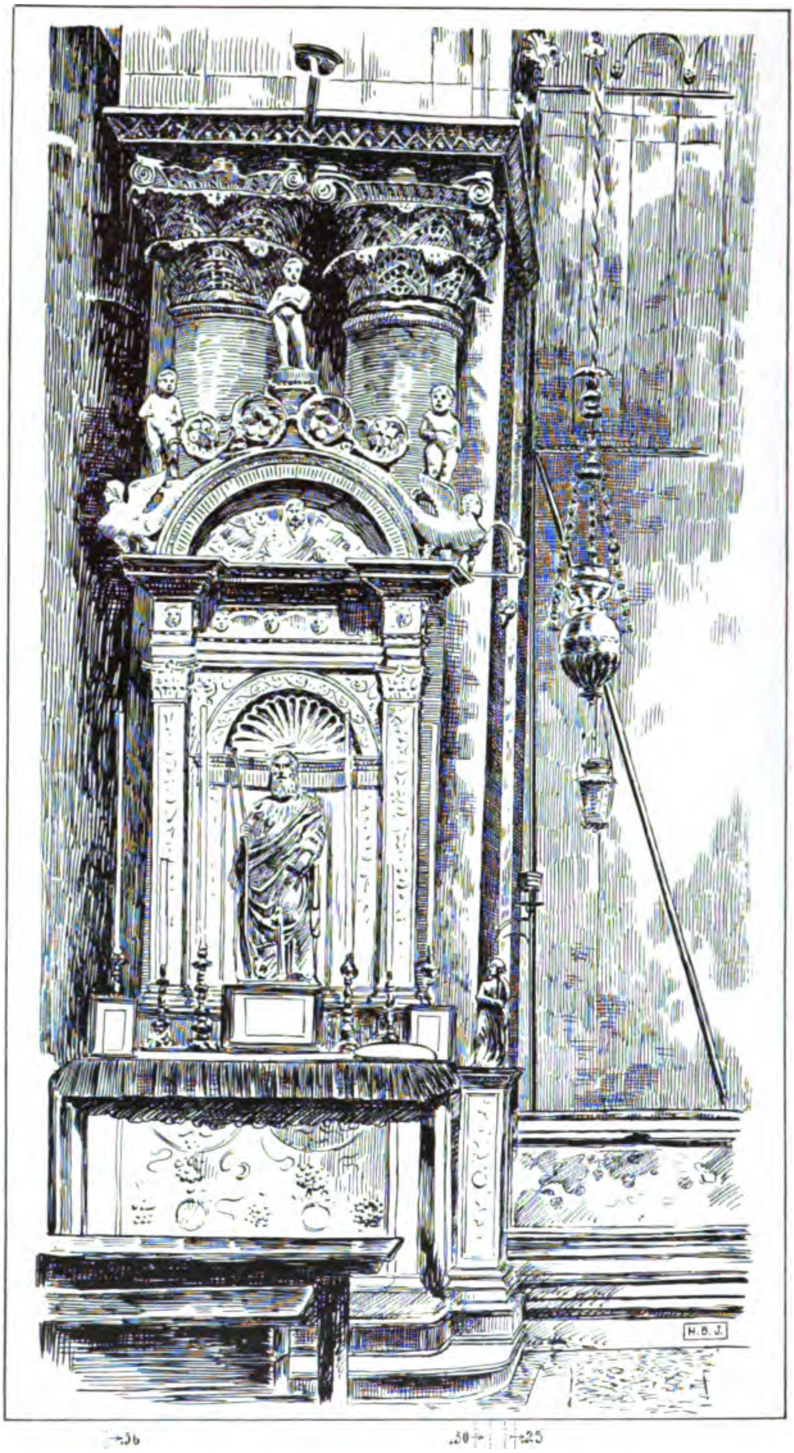


FIG. 28. ST. MARK'S. EAST PIER, SOUTH TRANSEPT, AND PILASTER IN THE REAR.

Accurate drawing from a Survey enlargement of 1901. The photograph was taken to show the plumb-line hanging on the wall pilaster, which leans .25, with line of 16 feet. This wall pilaster is thus constructed in parallel lean with the foreground pier. Compare Plan 4. The foreground pier is the same as shown in Fig. 27. The wall pilaster is shown more clearly, as regards situation and separation from the pier, in Fig. 34.

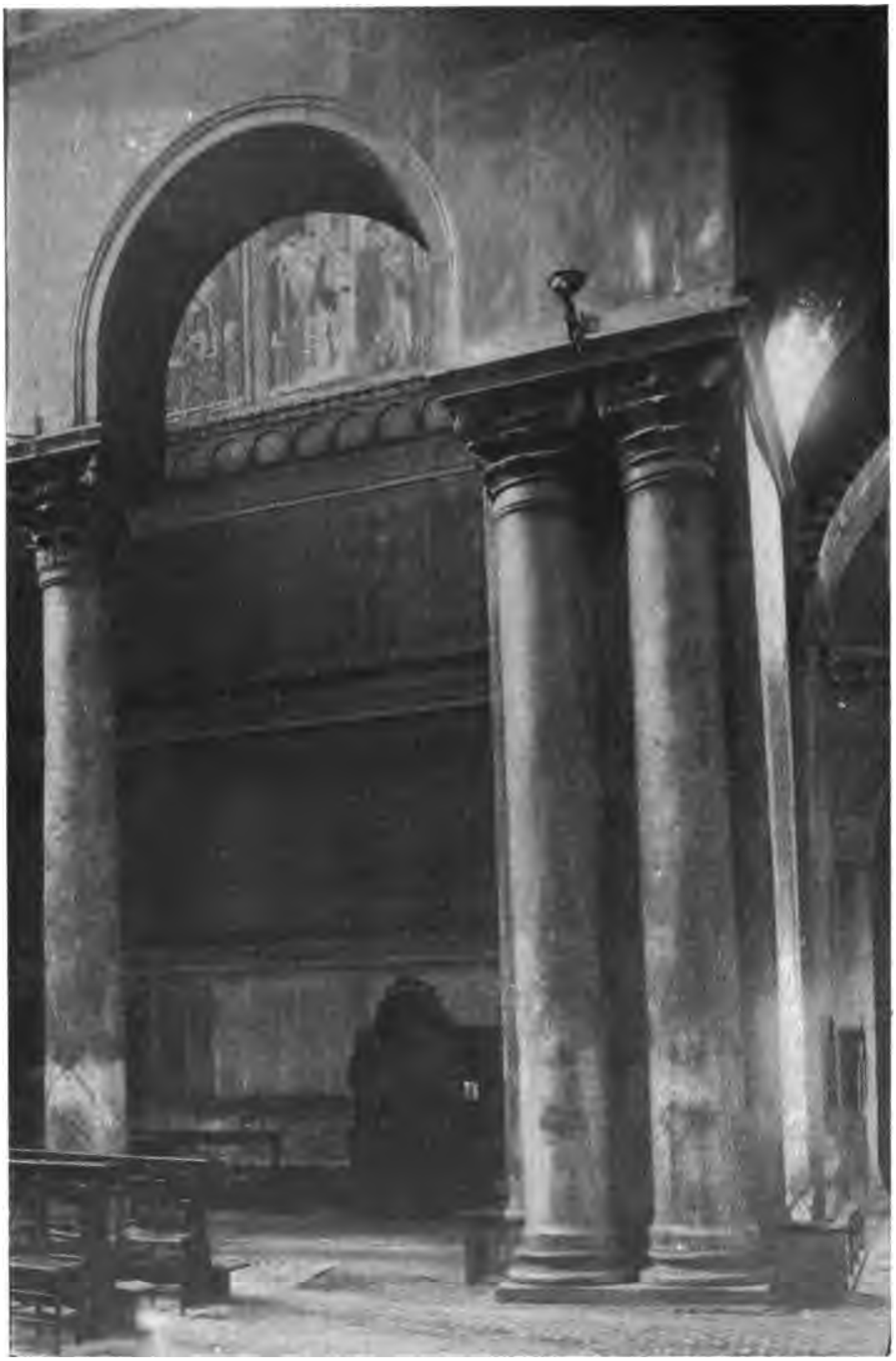


FIG. 29. ST. MARK'S. WEST PIER, SOUTH TRANSEPT, AND WALL OF THE SOUTH (RIGHT) AISLE, LOOKING WEST.

From a Survey photograph of 1895. Showing the upper wall of the right aisle in the direction opposed to that of Fig. 26. Compare Fig. 4. The view shows the perfect form of the arch in the transept and the diminished lean of the transept column. Compare Fig. 35 for the adjacent arches and columns. For contrast in the plumbs on opposite sides of the pier, compare text, p. 77.

into the aisle of the choir in the pilaster which faces the east wall of the south transept (Fig. 27).

This leads us to consider the points in this series of measures at which even the suggestion of accidental movement by thrust or subsidence is impossible. One of these is the point just indicated where the lean of .40 is entered. This pilaster is a solid portion of the south transept east wall.

On the opposite side of the same pilaster (Plan 4) we read the measure .25 (line of 16 feet). Here the pilaster is purely a decorative formula and yet it continues the lean, parallel with the sides of the piers which are in line with it in the transept.

Fig. 28 shows a plumb-line hanging beside this pilaster.

As regards questions of movement, or thrust, we also notice the engaged column entered in the plan as leaning .35 against the entire length of the west wall, south transept. Fig. 26 shows this column and the plumb-line.

Fig. 29 is a view looking back down this south aisle toward the west entrance. The columns facing the pier have been plumbed and are entered on the plan as leaning off .50 each, or 6 inches each. The pier itself has been plumbed as leaning south .60 at one angle and .47 at the other (on the north side) or an average lean of over 6 inches on the side which lines with the aisle. It was on this pier that the observation of 1870 was first made as regards the oblique cutting of the casing (p. 25).

No attention was paid to the pier casings in 1895 or 1901, as it did not seem necessary to descend to this detail, but the conclusion based upon them in 1870 is now proven to be a valid one.

We have so far confined our attention to the south aisle. Plan 5 will enable us to compare the north aisle with it. The same general facts are found here, with the qualification that the wall measures are not quite uniform. There are indications of a repair at the point where the entry of .03 toward the south is found on the plan, and more exact information is needed here as to repairs which may have obliterated the old construction. On the other hand, the facts are uniform for all the engaged columns and these determine the vertical effect by their heavy projection.

Fig. 30 shows one of these columns with a plumb-line. The inclination is 6 inches. This column leans against the entire length of the north transept west wall. Here again the theory of thrust or accidental movement must be abandoned. Moreover, on the opposite side of the north aisle wall the engaged columns lean in the direction opposed to those inside the same wall (Plan 5). This arrangement is connected with the construction of a spread, or widening, in the verticals of the north vestibule (Plan 14 or Plan 3).

We now return to Plan 5, in order to notice the correspondences

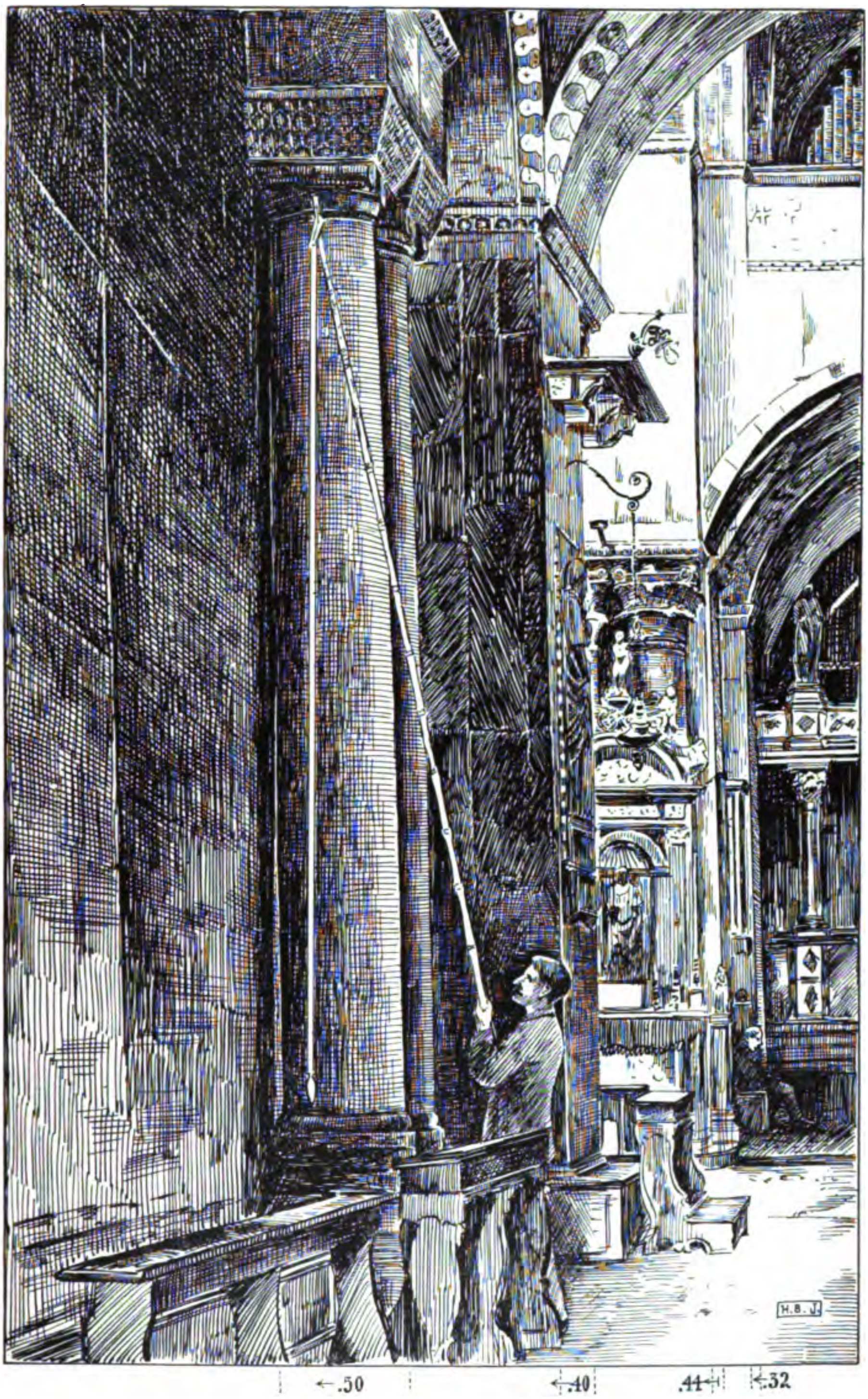
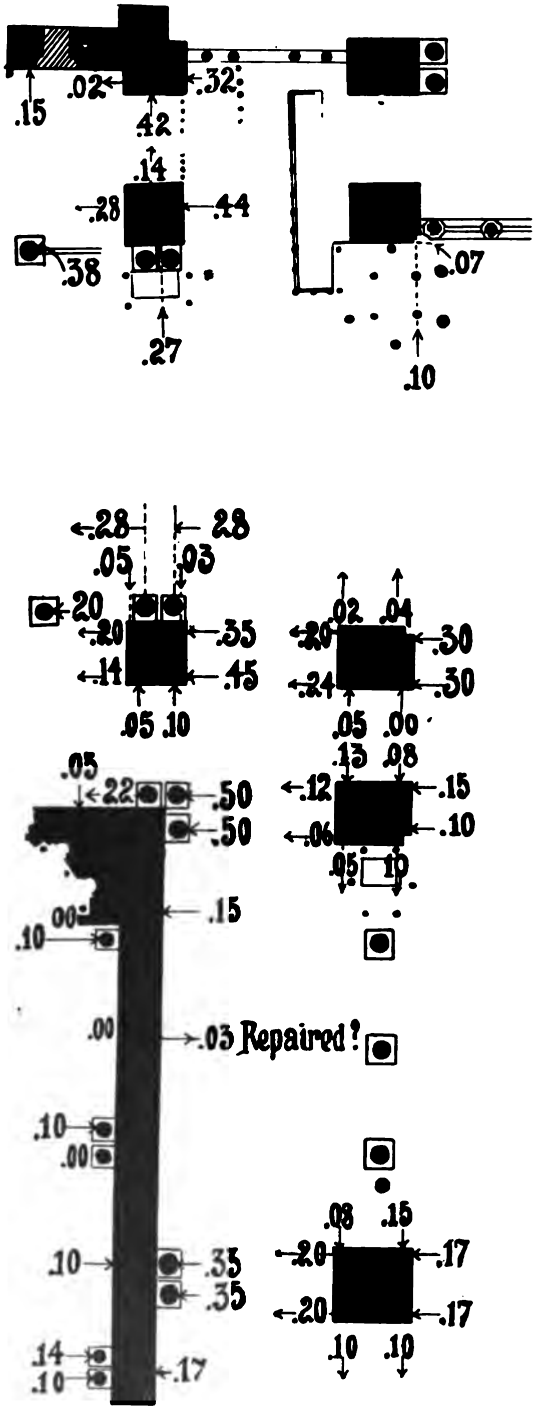


FIG. 30. LEFT (NORTH) AISLE OF ST. MARK'S.

Accurate drawing from a Survey enlargement of 1901. Showing a plumb-line on the engaged column and continuation of parallel leans in the transept piers and in the aisle of the choir. Compare Plan 5, from which the plumb measurements under the drawing are taken. The entry of .40 is an average for the double measures on the plan (.35 and .45).

with the south aisle as regards the continuation of the leaning verticals through the transept and into the aisle of the choir.

At the beginning of the choir aisle we find the entry .32 for the pilaster terminating the north transept east wall. Here again is a point where accidental movement is out of the question. The entry of .02 north, on the opposite side of this pilaster practically represents a perpendicular and does not repeat the interesting continuity of parallels observed at the corresponding point in the south transept, as shown by Fig. 28.



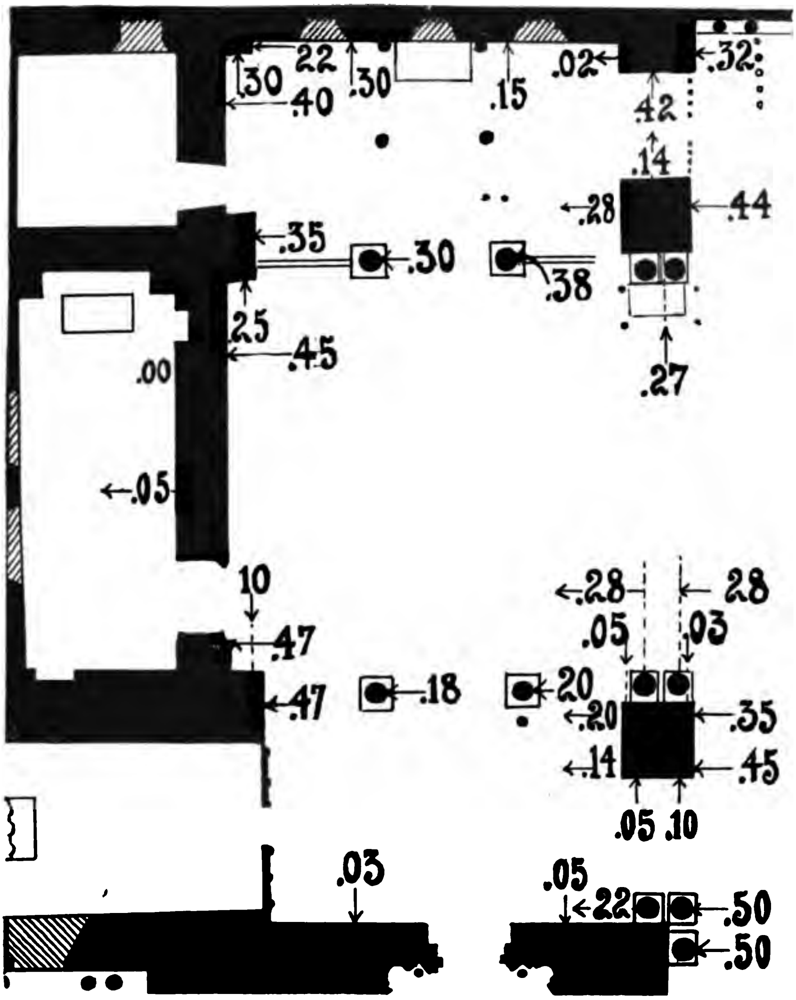
PLAN 5. LEFT AISLE OF ST. MARK'S.

The Transepts.

We now turn into the transepts (Plans 6, 7) and notice; first, that all four columns, in each transept (columns as distinct from piers), continue, with closely corresponding measurements, as regards their own verticals, but in much less amount than the aisle sides of the adjacent piers, the north and south leans of the aisles and nave.

There is one columnar lean of .38: north transept, east side; but the average for eight columns is only .26. There is no exception to the rule that the column next the pier leans more than the one next the wall. Most remarkable is the fact, to which there is no exception, that every one of the four piers adjacent to the transept columns leans heavily on the side which lines with the aisle, but leans considerably less on the side adjacent to the column. Thus in the north transept (Plan 6) the average lean of the west pier is .40 on the aisle side and .17 on the column side. (These averages are obtained by adding together the two measures on one face of the pier and dividing by two.)

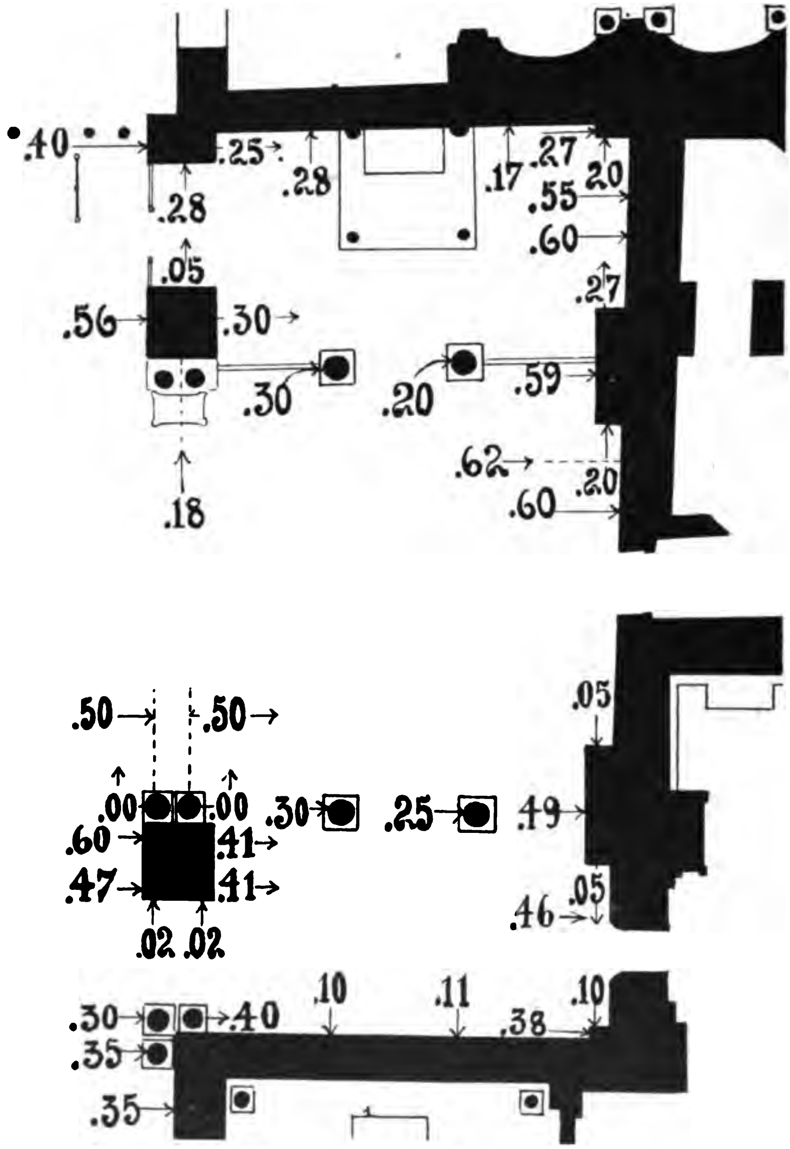
The east pier in the same transept leans average .44 on the aisle side and average .28 on the column side. In the south transept (Plan 7) the west pier leans average .53 on the aisle side and average .41 on the column side (compare Fig. 29). The east pier in the same transept leans .56 on the aisle side and .30 on the column side (compare Figs. 27, 28).



PLAN 6. NORTH TRANSEPT OF ST. MARK'S.

Sectional portion of Plan 3. Plumbs for a line of 15 feet on all transept walls and columns. Figs. 22, 31, 32, relate to this plan.

The uniformity of these variations could not well be accidental and movement due to thrust or subsidence would have been the same on two opposite sides of one pier. An obvious explanation would be that the columns of the transept are placed in line with the engaged columns which face the piers and are not in line with the piers themselves. These piers have therefore no counter thrust from the transept arches to assist in preserving their equili-



PLAN 7. SOUTH TRANSEPT OF ST. MARK'S.

Sectional portion of Plan 3. Plumbs for a line of 15 feet on transept walls and columns. Figs. 33, 34, 35, 36 relate to this plan. Figs. 37, 38, are gallery views in this transept.

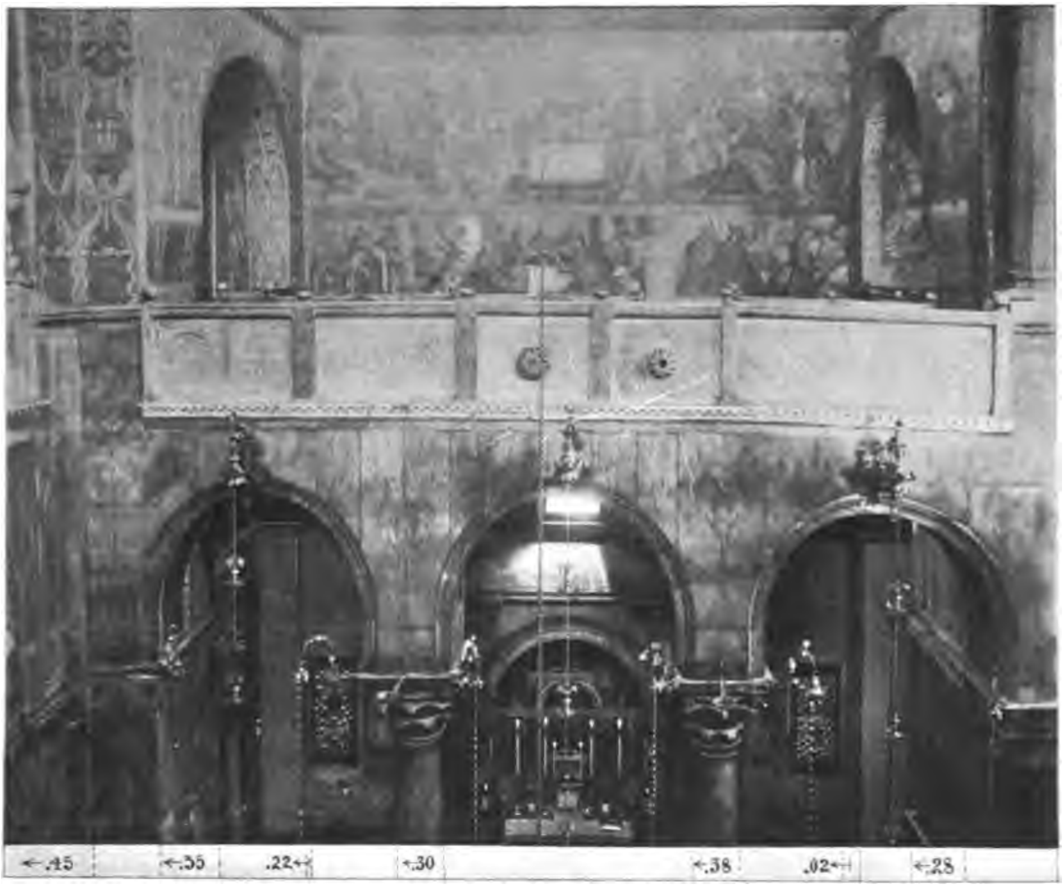


FIG. 31. ST. MARK'S. NORTH TRANSEPT, EAST GALLERY.

From a Survey photograph of 1895. Showing the northward lean of the north wall. For plumb from the parapet, compare Fig. 32. The measures below the picture are pavement plumbs, line of 15 feet. Note the pilaster in northeast angle of the transept aisle, with lean .22. Compare Plan 6. The arches are true. The view also shows a horizontal curve in elevation of the gallery parapet. Compare Figs. 33, 34, 35 for the south transept.

brium. Therefore the leans were diminished on the outside of each pier as a means to stability. This, at least, is a plausible explanation of a curious fact.

It is also to be remarked that, in spite of the leans of these piers and of their engaged columns, the arches of the transepts are perfectly true (Figs. 29, 31, 34, 35).

The Transept End Walls.

From the columns of the transepts we pass to the north and south walls of the transepts (Plans 6, 7). Here the leans increase to a phenomenal extent. In three instances the pilasters of the

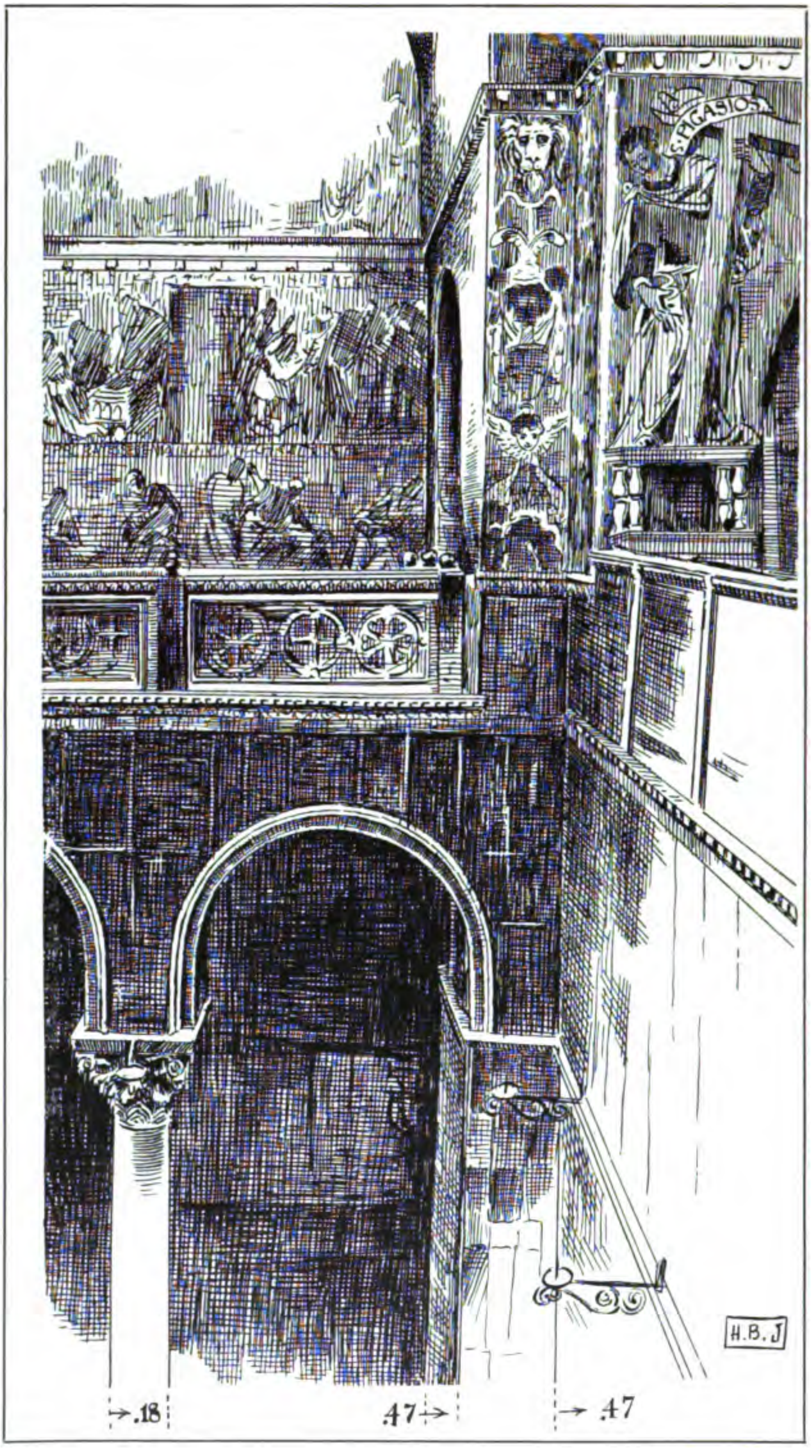


FIG. 32. ST. MARK'S. NORTH TRANSEPT, WEST ANGLE.

Accurate drawing from a Survey photograph of 1895. Under the drawing are plumbs from the pavement, with line of 15 feet (Plan 6). By plumb from the parapet (about 33 feet) the pilaster leans north 16 inches (the same average amount for the entire north wall). Plan 6 shows approximate perpendiculars on the opposite side of the same wall. The arch adjacent to the pilaster is true. The adjacent column leans .18, or about 2 inches. Compare Fig. 31 for the opposite angle of the wall. Compare Fig. 33 for the south transept.

end walls lean twice as much or over twice as much, in the same height, as the columns do. In the north transept the fourth instance shows no great change (east side). The adjacent arches are true in all cases; Figs. 31, 32, north transept; Figs. 34, 35, south transept.

At this point, we are able to supplement the plumbs from the pavement by the plumbs which have been taken from the galleries. Before quoting these we shall, however, stop to notice that these north and south leans are not only found in the pilasters which are in line with the columns, but that they also appear in the wall surfaces, throughout their entire extent, including the pilasters in the transept aisle angles (Plans 6, 7).

The outward leans of these terminal transept walls are most remarkable. They are not appreciated by the eye as to their full amount, except by sighting, even when the observer has full knowledge of the measurements. These end walls rise only to the height of the galleries (Fig. 22). They terminate in parapets which also lean outward (Fig. 32).* Behind these are deep galleries reaching back to the exterior walls; whereas elsewhere the galleries are narrow passages standing free from the walls.

The broad pilasters which face these walls in line with the columns of the transept aisles, correspond to wall faces above, which rise to the springing of the arches (Fig. 32).

The plumbs of the ground-plan for these walls, represent less than half the height to the top of the parapets and the plumbs from the galleries must now be quoted.

By plumb from the top of the parapet in the west angle of the north transept (Fig. 32) the lean of the pilaster is 16 inches in 33 feet (approximate height).

By plumb from the top of the parapet in the east angle of the south transept the lean of the pilaster is 15½ inches in the same height. Fig. 33 shows the plumb-line which records this result and is the most remarkable picture of the entire series. This measure is an understatement, having been taken from a plumb-bob hanging level with the top of a confessional box.

By plumb of the face of the same wall near the center and to right of the door leading to the Doge's Palace the wall leans 13½ inches in 30 feet. (Fig. 35.) In this south transept gallery the central part of the parapet consists of an open railing which allows of dropping a plumb-line from the level of the gallery floor. The height is therefore less, than in plumbing from the parapet, as shown in Fig. 33. (In the north transept gallery the parapet is a solid wall, so that the line cannot be dropped from the floor level.)

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*This is a positive and remarkable fact for the solid parapet of the north transept and was one of the points which especially interested Signor Saccardo. I have no record for the open railing of the south transept gallery.

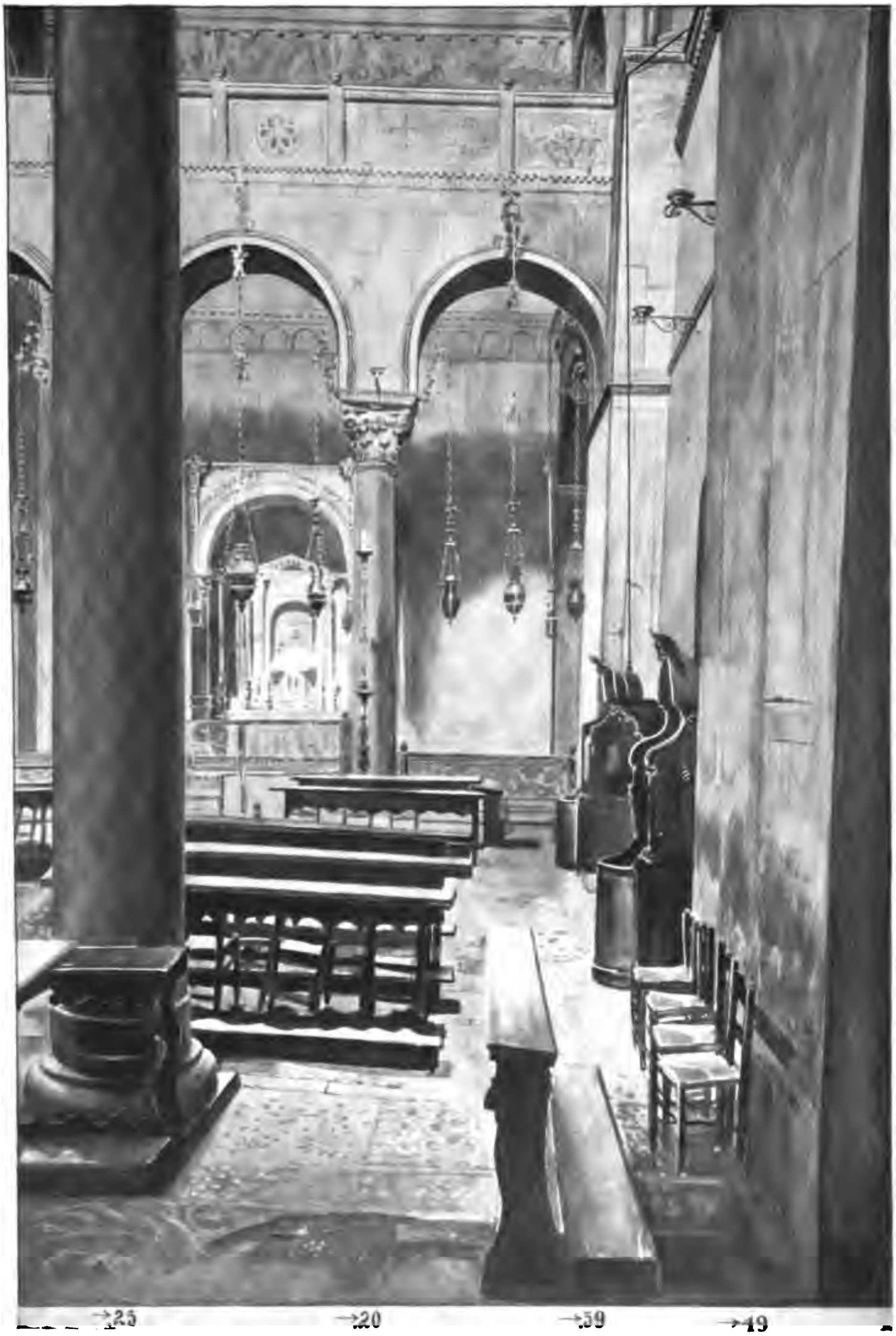

FIG. 33. ST. MARK'S. SOUTH TRANSEPT, LOOKING EAST.

Wash drawing from a Survey photograph of 1901. The plumb-line hanging on the pilaster records a lean of 15½ inches. The adjacent column leans .20, or under 2½ inches. The arches are true; compare Fig. 34. The wall as plumbed near the centre leans 13 inches, not including the parapet; line of 30 feet. Compare Plan 7 for pavement plumbs. The opposite side of the south wall (in the magazine) is not perpendicular, as in the north transept. The lean has the same amount on both sides (no entry in plan).

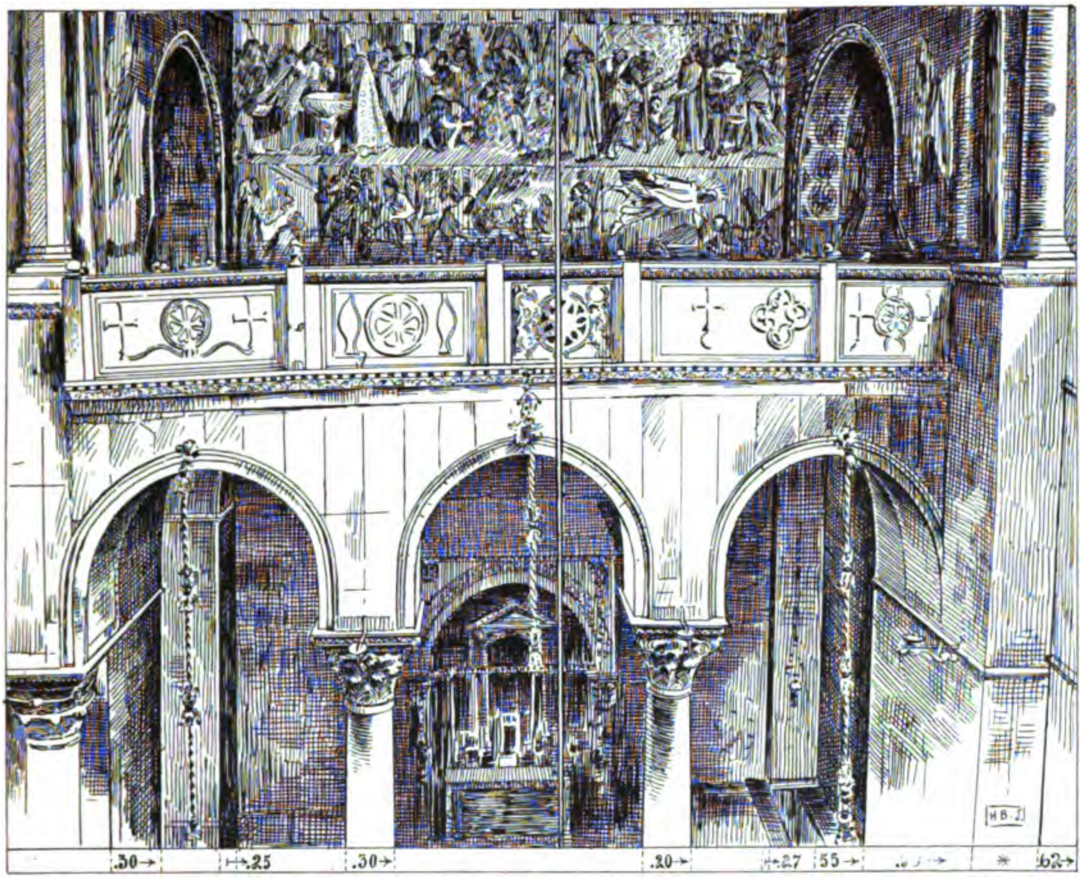

FIG. 34. ST. MARK'S. SOUTH TRANSEPT, EAST GALLERY.

Accurate drawing from a Survey photograph of 1895. See p. 101 for the apparent obliquity in elevation, of the parapet, as an illusion. Below the drawing are entries of pavement plumbs, from Plan 7. The star shows the locality of the parapet plumb as represented in Fig. 33. This view (Fig. 34) shows more clearly than Fig. 28 the situation of the wall pilaster with lean .25. It also shows the pilaster in the south-east angle of the transept aisle, with lean .27. The double leans of these pilasters, east as well as south, are entered on Plan 7. The curve in elevation of the gallery parapet is to be noted.

Let us now examine Fig. 33 with reference to the possible suggestion of accidental movement. In that case the wall would have moved away from the adjacent arch about 14 inches at the level of the top of the arch (the whole lean being more than 15½ inches to the top of the parapet). This arch itself is only 8 feet wide. It is perfectly true and the column which supports it only leans .20 or 2½ inches. This arch would have collapsed if the wall had gone over to the extent of 15½ inches.

Fig. 34 gives a better view of these arches and includes a series of natural plumb-lines which are furnished by the lamp chains. At

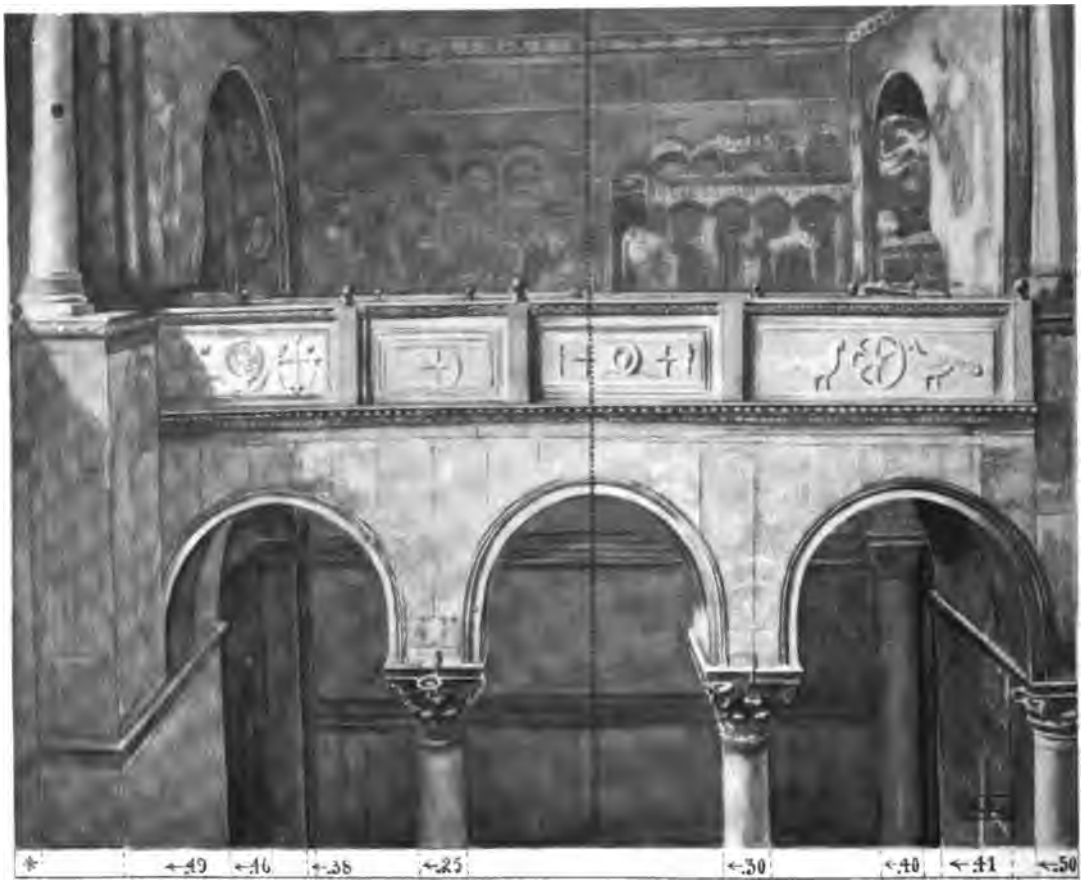

FIG. 35. ST. MARK'S. SOUTH TRANSEPT, WEST GALLERY.

Accurate wash drawing, from a Survey photograph of 1895. The star below the drawing is near the location of the gallery plumb of 13 inches lean for the wall (line of 30 feet). The pavement plumb .38 marks the pilaster in the aisle angle. Compare Plan 7 for the double leans. The column leans of .25 and .30 are to be compared with the pilaster (.49). The column and wall above this pilaster are perpendicular. The arches are true. The gallery parapet has a curve in elevation.

three other corresponding points the conditions are the same, as regards the ruin which would have befallen the arches if the walls had moved outward accidentally. These points are shown by Figs. 35, 31, 32.

It is hardly necessary to draw attention to the fact that in no instance does the column next to the wall pilaster show the same lean. In the pavement measures for the north transept (Plan 6), the west pilaster leans .47 and the adjacent column leans .18. The east pilaster leans .35 and the column leans .30 (the only close approximation). In the south transept (Plan 7) the west pilaster leans .49 and the column leans .25. The east pilaster leans .59 and the column leans .20.

It has already been stated that the leans of these end walls were first observed in 1895,* that they were examined by Signor Saccardo in my company, and that they were included in his verdict as to construction, although not specifically mentioned in his certificate.

In view of this verdict, it is really superfluous to point to the lines of resistance in the side walls of the chapel of St. Isidore (Plan 6) and in the walls of the exit passage to the Doge's Palace (Plan 7), or to point to the east and west walls of the transepts, up to which these slopes are carried even in the pilasters at the angles of the transept aisles.

It may, perhaps, be worth mentioning that both of these transept end walls lean against thrust. The north wall leans against the vaulting of the chapel of St. Isidore and is perpendicular inside that chapel. The south wall leans against the thrust of the vaulting of the magazine and of the chapel of the treasury. Inside the magazine the inclination continues; the chapel wall was inaccessible.

Before leaving Venice I took the levels in both galleries of the south transept. I found the east gallery of the south transept (Fig. 34) to be level within .07, and the west gallery to be level within .10 (Fig. 35). This proves that the depressions of the pavement, however caused, have not affected the galleries or the end walls. An apparent obliquity in Fig. 34 is an optical illusion, as explained at p. 101. The irregularities of the pavement are considered at p. 104.

As regards the piers and walls of the transept galleries above the line of the parapet, they return very nearly, if not quite, to the true perpendicular in the south transept, Figs. 34, 35. At one angle of the north transept (east side) the upper wall is nearly perpendicular (Fig. 31). The upper wall of the west angle shows a continuation of the inclination which is found in the pilaster below but in less amount (Fig. 32). The facts regarding the perpendiculars above the leaning walls are of the highest importance. They are especially well shown in Fig. 35, but also in Fig. 34; if it be noted that the wall face is more closely perpendicular than the engaged column. The drawings for these illustrations give strictly accurate reproductions of the verticals of the survey photographs. In both photographs and drawings the facts may be tested by the natural plumb-lines which are offered by the lamp chains in the centres of the pictures.

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*Architectural Record, Vol. VII., No. 2, 1897; Fig. 6.

East and West Widening of the Transepts.

The transepts have another system of leaning verticals, which is at right angles to the one so far described; that is to say, a system of widening from east to west (Fig. 22). This system crosses the system of the nave and relates to the transverse direction of the transepts. But whereas in the transept system so far described, the verticals are nearly, or quite, perpendicular above the parapets, with marked leans below; this second system shows a contrary arrangement, at least on the west side of both transepts. On the west side of both transepts the westward leans are accentuated above as they are in the nave, but they are not found as regards the piers. Plan 3 gives a connected view of both transepts.

The same piers which lean south .60, .47 (Plan 7) and north .45, .35 (Plan 6) and with engaged columns also leaning south .50, .50, and north, .28, .28; are practically perpendicular, as regards the east and west direction. In the adjacent piers similar facts are observed.

On the other hand, Fig. 36 shows the westward lean of the engaged column in the west gallery of the south transept. The capital is set, however, so as to tip forward; undoubtedly so as to avoid the foreshortening of its carved decoration. Fig. 36 is an accurate wash drawing from a Naya photograph.

Fig. 37 shows the corresponding westward lean of the companion column, as photographed in the west gallery of the south transept from the opposite direction, and again with a capital which does not lean westward, but which is set to a level. The plumbing of this column gives a lean of .24, or about 3 inches, with a line of length 9.64.

Fig. 38 shows the leaning column, corresponding to the last, in the op-

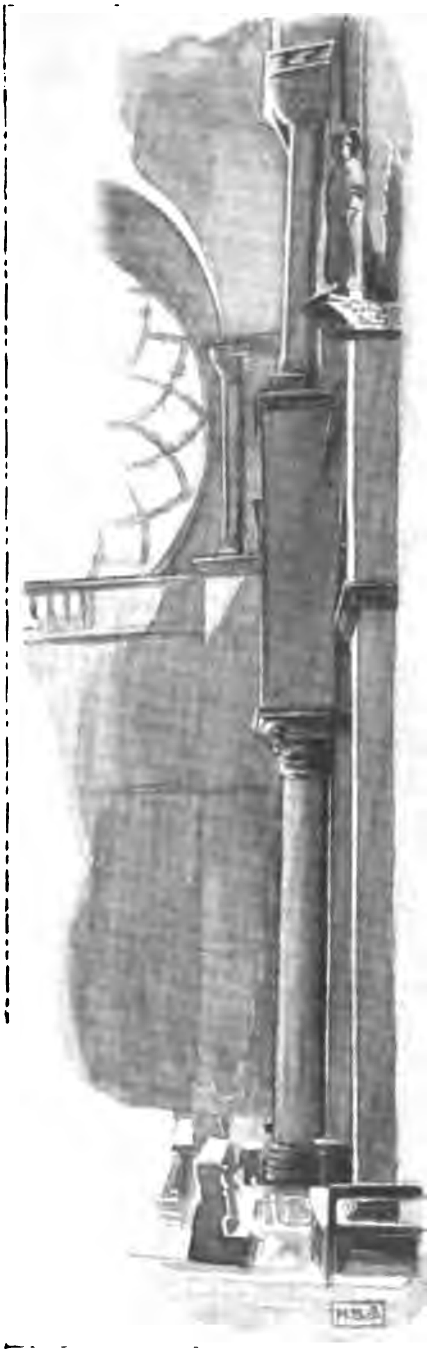


FIG. 36. ST. MARK'S. SOUTH TRANSEPT, WEST SIDE, LOOKING SOUTH.

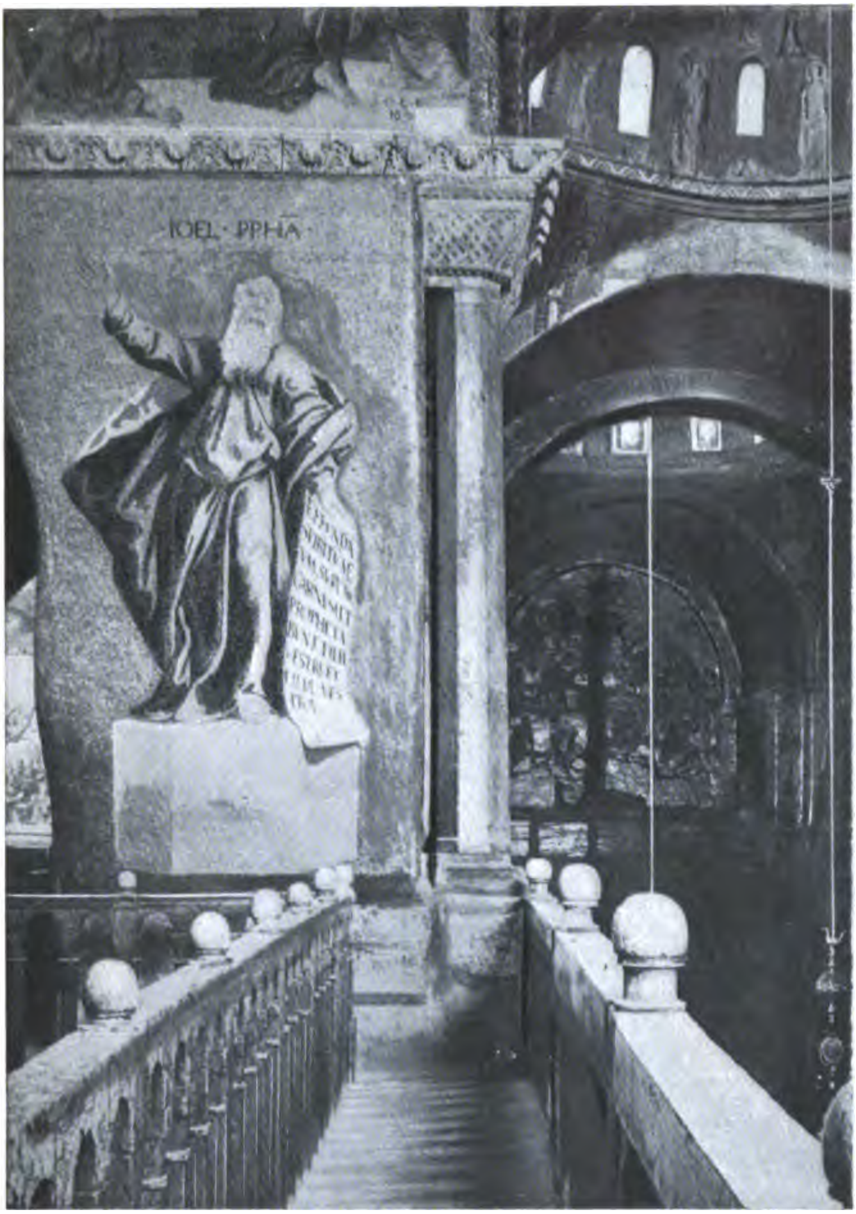


FIG. 37. ST. MARK'S. SOUTH TRANSEPT, WEST GALLERY, LOOKING NORTH.

From a Survey photograph of 1901. Showing column which is the mate of the gallery column shown by Fig. 36. By plumb measurement this column leans west .24 or 3 inches (line of 9.64). The capital is set to dip downward and does not lean back with the column. Typical for the westward widening on the west side of both transepts. Compare Fig. 38 for a column of the east gallery.

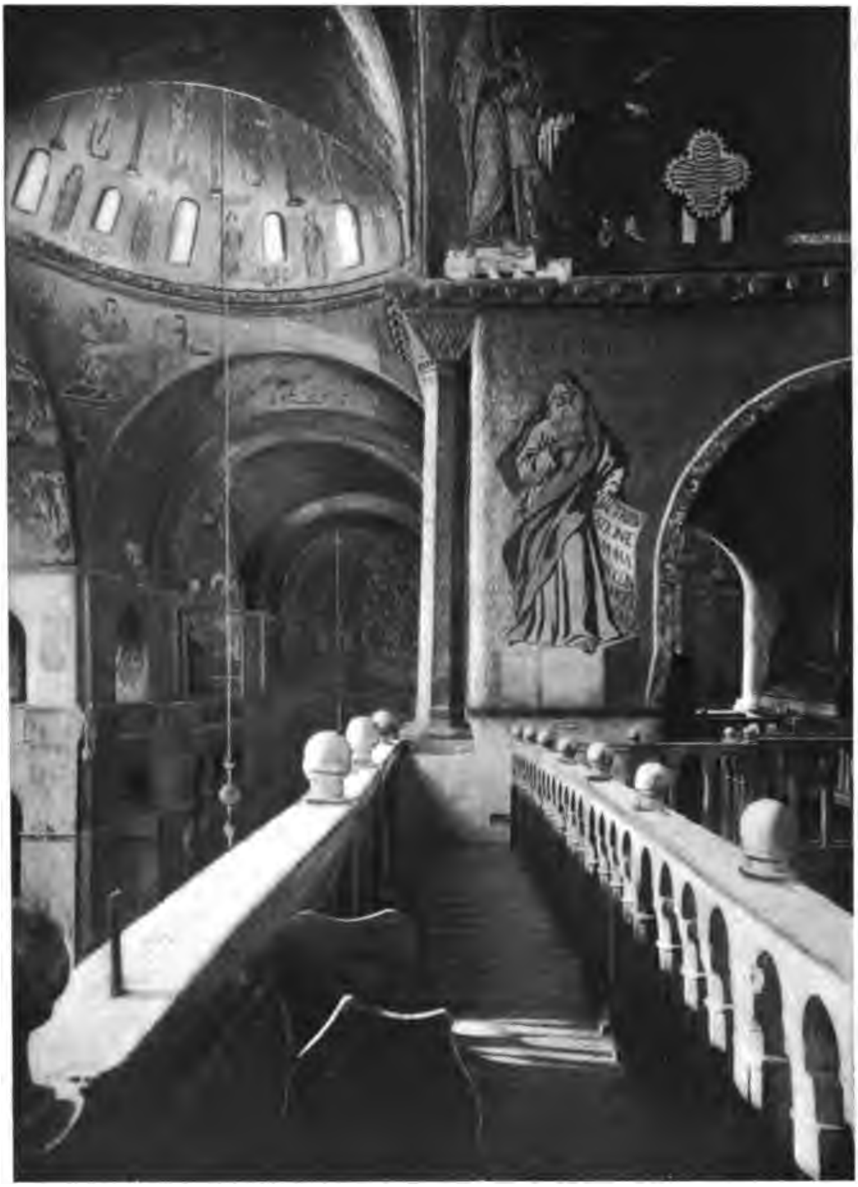


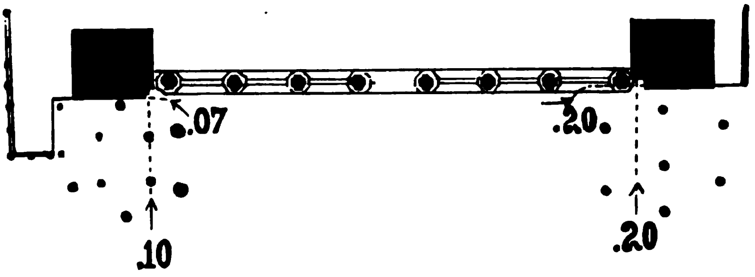
FIG. 38. ST. MARK'S. SOUTH TRANSEPT, EAST GALLERY, LOOKING NORTH.

From a Survey photograph of 1901. Showing a leaning column, to be compared with the plumb-line of the lamp chain. The column is opposite to the one shown by Fig. 37. For the north transept compare Fig. 22 for the leaning columns of the east gallery.

posite transept gallery. The enlargements of these photographs up to 25x35 inches, in the Brooklyn Institute Museum, are very valuable for illustration of the more remote columnar leans on the gallery walls of the north transept.

As regards the piers on the east side of the transepts, all four of them lean east, from the pavement up, in amounts which are shown by Plans 6, 7, 8, and by Plan 3, which has the advantage of showing these piers in one connected line. The plumbs of the piers which are faced by the pulpits are especially interesting (Plan 8, Fig. 39).

We next observe the remarkable fact that these east and west leans are repeated in the same pilasters of the north and south transept end walls, which have been already described as having the phenomenal outward (north and south) leans. We now find the same pilasters showing also east and west leans (Plans 9, 10), obviously under conditions eliminating any possible suggestion of accident.

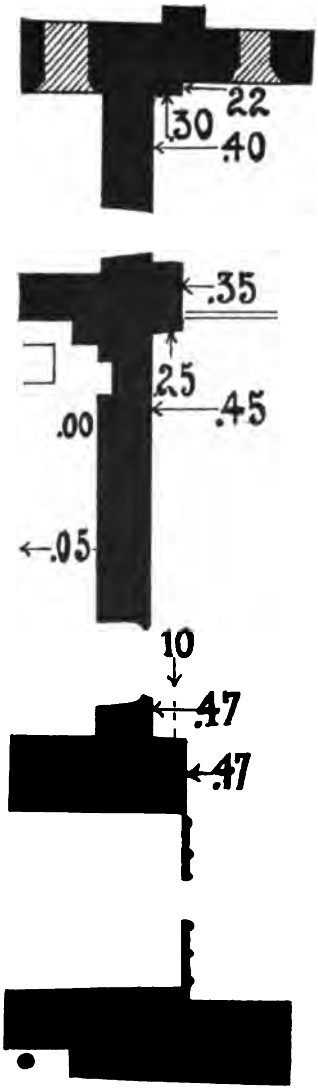


PLAN 8. ST. MARK'S. THE ENTRANCE TO THE CHOIR.

Sectional portion of Plan 3. Compare Fig. 39. Pavement plumb with a line of 15 feet. Showing the double leans of the piers, as called for by the intersection of the north and south widening of the nave and transepts with the east and west widening of the transepts. Compare Plans 6, 7, or Plan 3, for the entire line of eastward leans, which extends to the pilasters of the north and south transept walls.

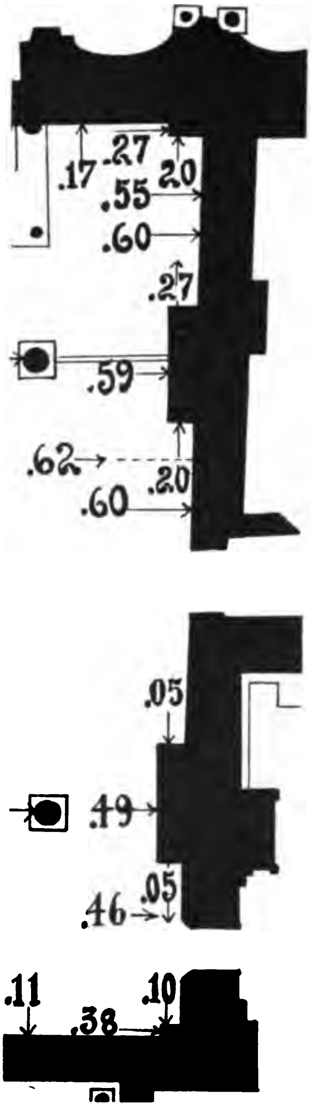
Plans 9, 10, also show that the same east and west leans are repeated in the pilasters of the transept aisle angles which have already been specified for north and south leans. Thus each one has a double lean, like the pilasters just mentioned. (No measures were taken in the northwest angle of the north transept on account of the modifications in plan which are connected with the exit.)

We next notice the east transept walls (Plans 11, 12); with leans uniformly east; and with pilasters, at the turn into the choir, also showing double leans. The north and south leans at these points



PLAN 9. ST. MARK'S. NORTH TRANSEPT, NORTH WALL.

To illustrate the east and west widening system of the three pilasters. The northeast angle pilaster, leaning .30 east and .22 north, is shown by Fig. 31, on which the eastward plumbs are omitted.



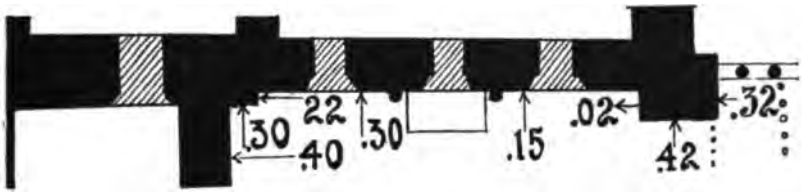
PLAN 10. ST. MARK'S. SOUTH TRANSEPT, SOUTH WALL.

To illustrate the east and west widening system of the four pilasters. The southeast angle pilaster, leaning .20 east and .27 south, is shown by Fig. 34, on which the eastward leans are omitted. The southwest angle pilaster, leaning .10 west and .38 south, is shown by Fig. 35, on which the westward plumbs are omitted.

have already been described in connection with the aisles of the nave (pp. 74, 76, Fig. 27).

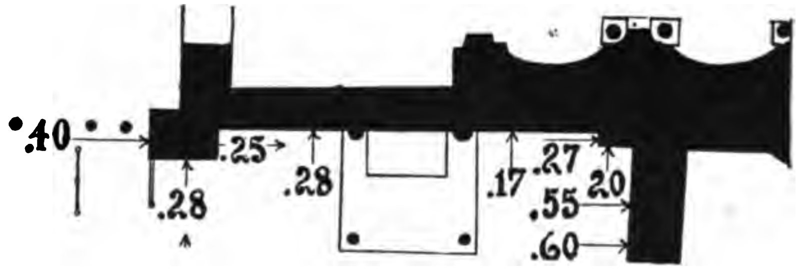
Here again are points where the constructive facts are beyond cavil of any sort.

The west walls of both transepts show uniform outward leans, but of insignificant amount (Plan 3). It has still to be ascertained what the facts may be above the height of 15 feet. The repetition of the same slope in the pilaster of the southwest aisle angle of the south transept is significant and leads us to pay more attention, than we otherwise might do, to the small amounts of leaning in these walls. The slight amount of these measures for the height recorded, repeats a peculiarity already described in the west line of transept piers which corresponds to them (p. 86). These have been already noted as practically perpendicular as regards east and west direction (Plan 3.)



PLAN 11. ST. MARK'S. NORTH TRANSEPT, EAST WALL.

To illustrate the eastward widening system and the double lean at the choir angle, as called for by its intersection with the north and south system. This pilaster, leaning .42 east and .32 north, is shown by Fig. 30, on which the entry of .32 north denotes it.



PLAN 12. ST. MARK'S. SOUTH TRANSEPT, EAST WALL.

To illustrate the eastward widening system and the double lean at the choir angle, as called for by its intersection with the north and south system. This pilaster, leaning .28 east and .40 south, is shown by Fig. 27, on which the entry of .40 south and the plumb-line denote it. The opposite side of the same pilaster is shown by Fig. 28.

Widening of the Choir.

As regards the casing wall of the choir, plumbs were taken on both sides. The plumb-line measurement on the south side of the choir is shown by Figs. 40, 41; Plan 13. For the length of line used (obstruction farther down) the same amount of inclination was found on both sides, viz., 4 inches. The entire slope from pavement to parapet is probably about 8 inches. No plumbs were

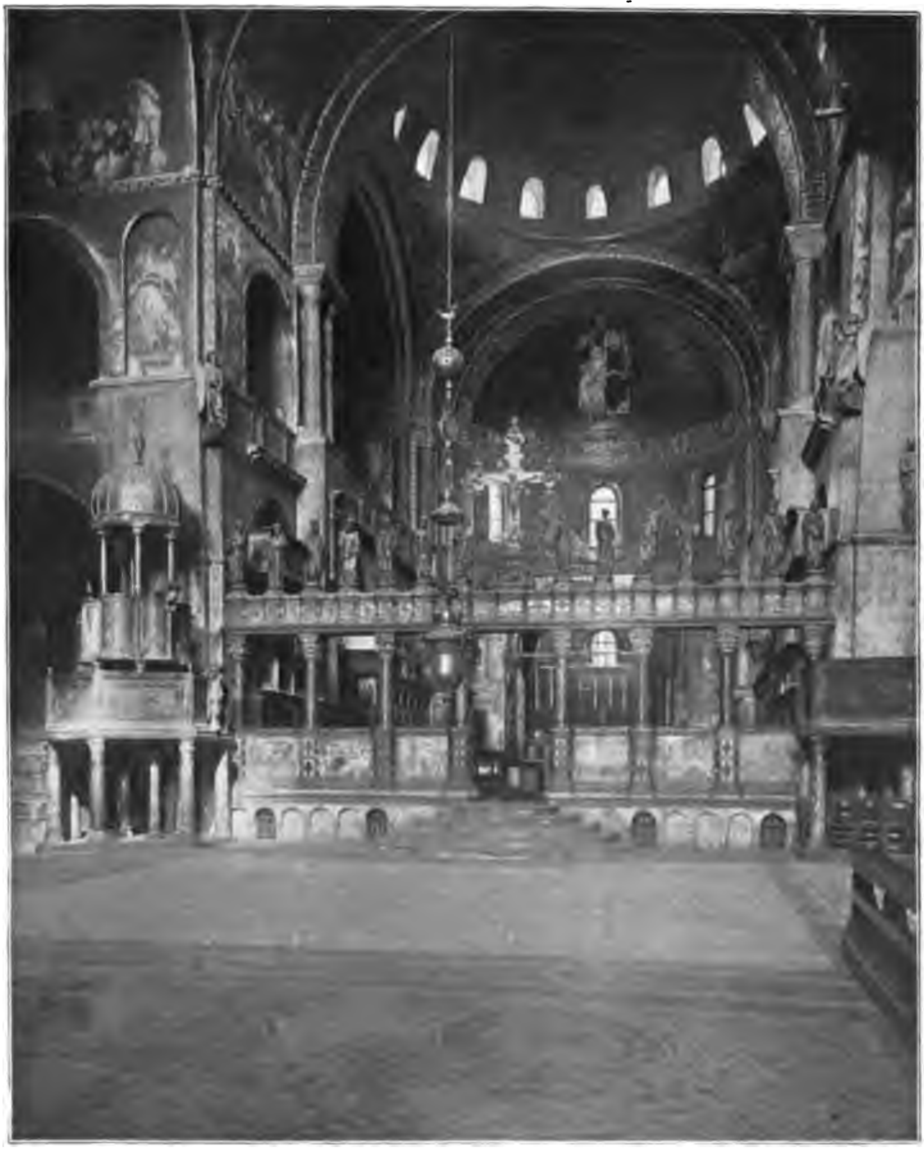


FIG. 39. THE CHOIR OF ST. MARK'S.

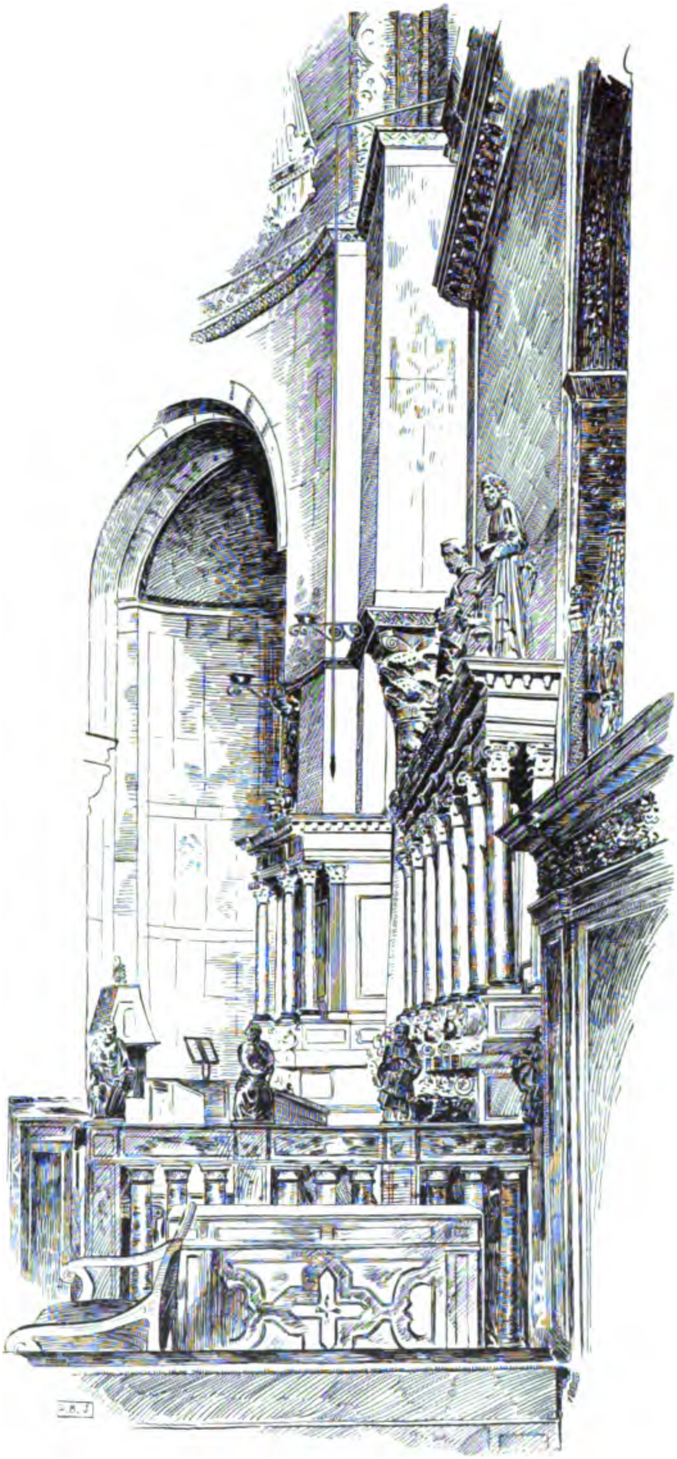


FIG. 40. ST. MARK'S. VIEW OF THE APSE.

Accurate drawing from a Survey enlargement of 1901. The plumb-line appears in the original photograph. The lean is 4 inches at the plumb-bob. Compare Fig. 41 and Plan 13.

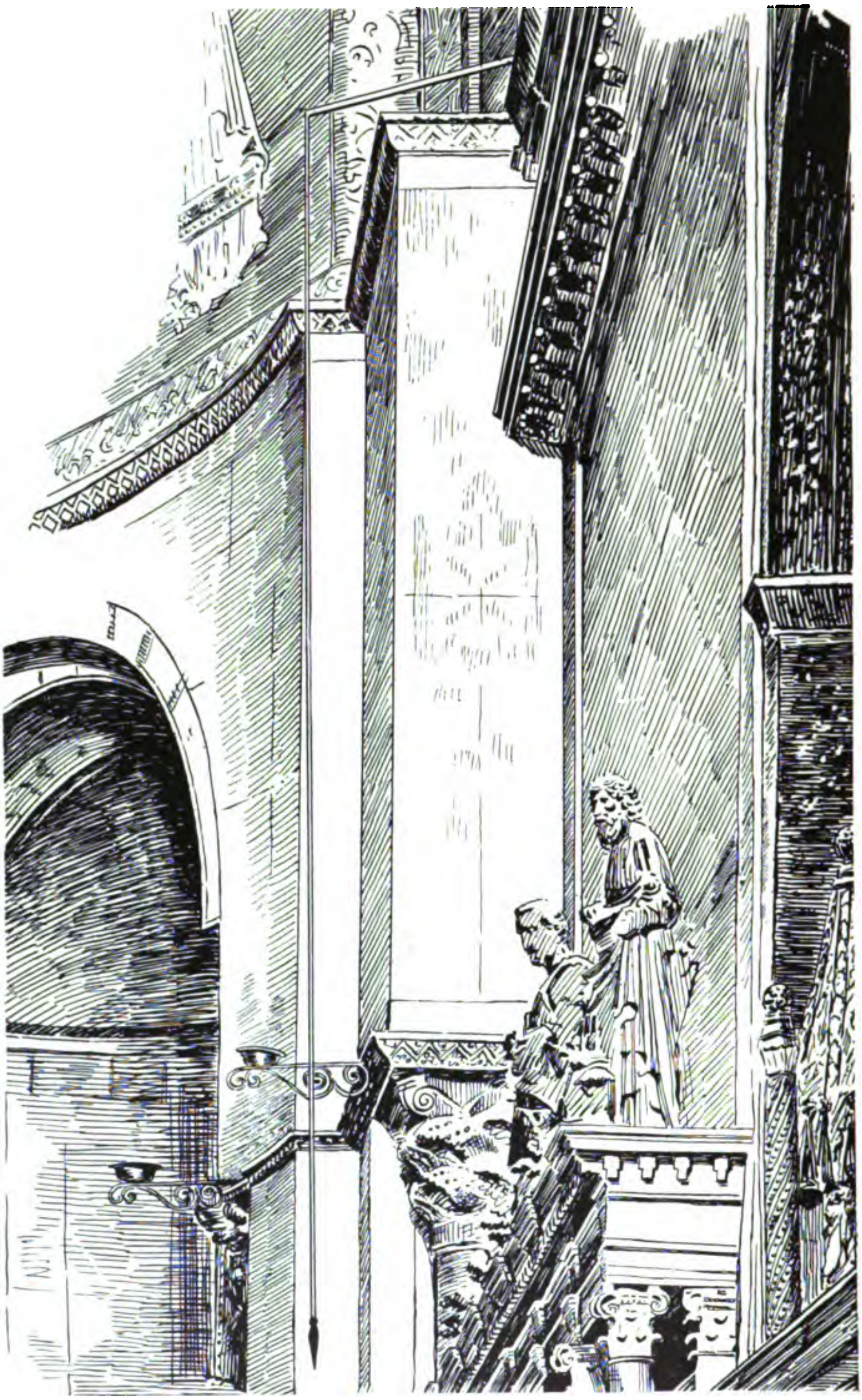
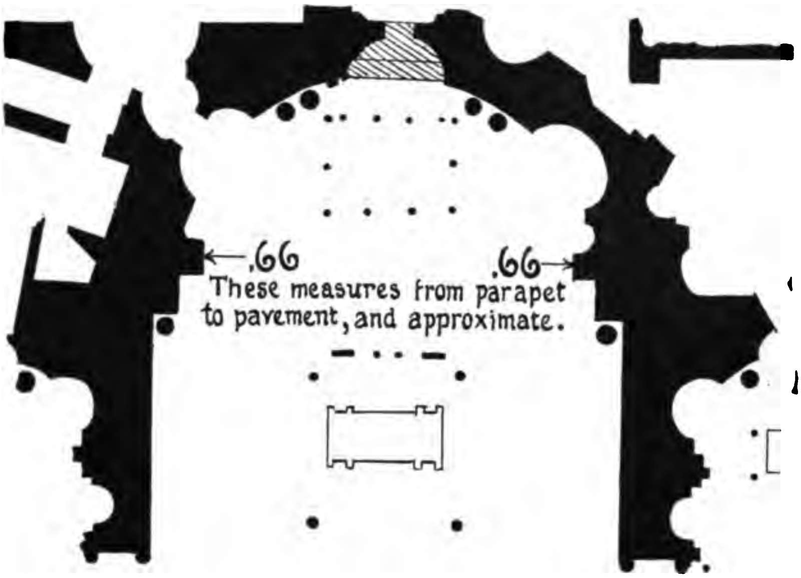


FIG. 41. ST. MARK'S. PLUMBING THE APSE.

Detail of Fig. 40. Accurately drawn to scale, from an enlargement of the original photograph. The same amount of widening was plumbed at the corresponding point on the opposite side of the choir. Compare Plan 13.

taken for the upward direction in the galleries of the choir. The downward tilt of the capital of the engaged column in the right choir gallery is very notable (Fig. 39). This appears to be another case of an arrangement intended to evade foreshortening of the decoration of the capital.



PLAN 13. ST. MARK'S. THE APSE.

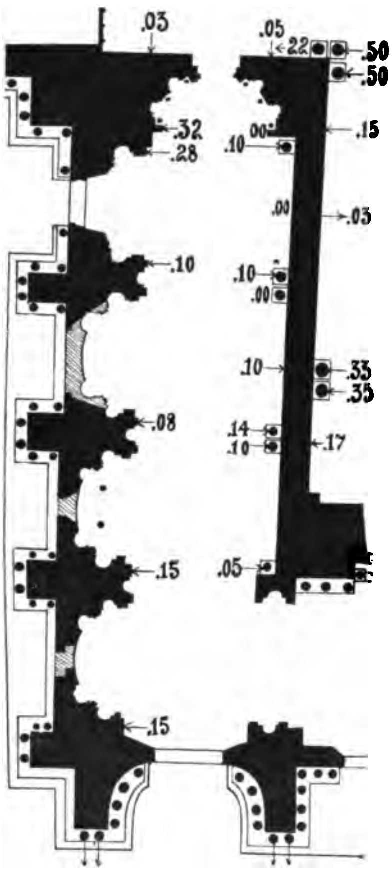
To illustrate the location of the plumb-line in Figs. 40 and 41. These measures are the only ones entered on any of the ground-plans for plumbs from the gallery, and are approximations. The obstructions to accurate plumbing are shown by Fig. 40.

Westward Leans in the Nave.

We now return to the nave, in order to notice the westward leans of the piers (Plan 3). These are repeated in the engaged columns of the west (entrance) wall, which is perpendicular in the vestibule, on the other side of the gallery stairs. What the facts may be for the upper west wall has still to be ascertained. The measures for the limited height are not uniform in results on the northern half of this wall, but they are uniform as regards the engaged columns. The changes of direction in the wall may be due to repairs. It would have been easy to take plumbs from the gallery parapet, but I omitted to do this; not having realized until my return to the United States, that as far as piers and engaged columns are concerned, the facts are uniform with those in the transepts. This is an omission which results from lack of time to study carefully the results of the measures taken, while still in Venice. The omission of plumbs for the columns of the nave has the same explanation (Plan 3).

The Vestibules.

The vestibule measures have next to be considered. Plan 14 shows the north vestibule which also has a constructive widening.



PLAN 14. ST. MARK'S. NORTH VESTIBULE.

To illustrate the system of widening. The columns lean in opposite directions on opposite sides of the church wall. The length of plumb-line was 11.70, and the vestibule columns have about that height, exclusive of capitals.

The verticals of the west vestibule were not systematically plumbed, as there were indications that the columns on the right of the main central entrance had been reset during modern repairs.

Summary for St. Mark's.

We are now in a position to summarize the results of all these plumbs, as regards the correspondences of vertical direction.

There are eleven wall surfaces of the church, not including the vestibule walls, in which the system of an outward widening has been found. These walls are: the north wall of the nave; east, north, and west walls of the north transept; north and south inner walls of the choir (outer walls not plumbed); east, south, and west walls of the south transept; south wall and west wall of the nave.

In two of these walls the system is discovered in all of the engaged columns which give the dominant vertical effect to the aisles, although the measures, as found in the note-book record, are not uniform as regards direction for the walls themselves, up to the height attainable. On one of these walls (north wall of the nave) a survey photograph shows the lean in the wall itself at a higher altitude and at the same point where a perpendicular was found by the line. For both of these walls the question whether repairs may have vitiated some of the measures has still to be examined and plumbs from above have still to be taken.

The whole number of plumbs taken from the pavement inside the church and in the north vestibule was 169.

All of these plumbs show uniform and corresponding results, as regards direction of the verticals, in the dominant direction for the given member or surface, with the exception above mentioned and an insignificant exception in the north vestibule. One column is perpendicular in the north vestibule and has probably been reset. (Plan 14). The perpendiculars on the south wall of the north vestibule can hardly be regarded as exceptions. The wall is very low and the columns project from it at such short intervals as to control the vertical effect.

In all of those architectural members of the transepts, both pilasters and piers, where a double lean is called for, by the meeting or intersection of the two systems of dominant leans, the double lean is found.

Accuracy of Masonry Construction in St. Mark's.

Certain results as to the margin or limit of error in the mechanical accuracy of the masonry of St. Mark's may be gathered from a comparison of some of the measurements. Before these comparisons are made, it may be recalled that the appearances of rough construction are generally found in the galleries and in the surfaces which are covered by mosaics. In the marble casing of the church the close fitting of the slabs speaks for itself, and this presupposes careful cutting and accurate cutting, at least after the curves of the galleries have been recognized as constructive, together with certain other obliquities of the galleries which have been proven to be constructive at Pisa, and which probably are constructive here.

To take up the tests for accuracy we will begin with the south transept end wall (Plan 10). The plumbs run as follows (outside of the pilasters in the aisle angles):

.55, .60, .59, .62, .60, .49, .46.

The limit of error is therefore .16, or 1¾ inches in 15 feet.

The series of plumbs from the pavement for the north transept end wall (Plan 9) is as follows (omitting the aisle angle):

.47, .47, .45, .35, .40.

The limit of error is .12 or 1½ inches in 15 feet.

These discrepancies may, of course, be due to accidental movement, as well as to inaccurate building. We have already seen that the plumbs for the entire amount of widening in the nave tally within one inch, on the two sides, as regards the sum total, and that they also tally quite closely as compared for the three separate vertical divisions.

If we examine the entire series of plumbs for the east side of both transepts, including the aisle angles (Plans 11, 12) they are found to run as follows (the pilaster plumbs are entered in parenthesis):

.30, .30, .15, (.42); (.28), .28, .17, .20.

The slopes of the walls, as distinct from the pilasters, show an extreme variation, or error, of .15 or 1¾ inches. This corresponds to the limit of error in the end walls. The pilasters (measures in parenthesis), at the angles of the choir walls, vary .14, or about 1¾ inches.

Another test as to accuracy is obtained by comparing the measures for the vertical deviations in piers which were certainly meant to be perpendicular on two opposite sides.

For instance, the west transept pier in line with the south wall of the nave (Plan 4) has the following east and west measures: west side; .02, .02, lean east; east side; .00, .00. The limit of error here is .02 in 17 feet. The corresponding pier (Plan 5) in line with the north nave wall, shows inclinations on the west side of .05 and .10, leaning east; and inclinations on the east side of .03 and .05, leaning west. This pier must have been intended to be perpendicular as regards the east and west verticals. The limit of error is .10 in 17 feet.

It appears also that the accuracy of the masonry varies with the amount of widening which was desired. Thus it is clear that the columns in the north vestibule were set to a maximum lean of .10 in 11 feet, with one error of .05 and one column perpendicular, which we must consider an error of .10, unless it has been reset by a modern repair.

Some interesting conclusions are reached by comparing the piers of the nave. The leans on the nave side of the piers are given below:

South Side (Plan 4): .15, .15; .05, .05; .15, .17.
North Side (Plan 5): .17, .17; .10, .15; .30, 30.

Here the limit of error, as regards the two angles on the same side of any one pier, is .05. As regards the contrast of corresponding measures on opposite sides of the nave the limit of error is .15. As regards variation between the piers of one line, the limit is close to .15.

Let us next consider the opposite sides of each separate pier. We begin at the left nave pier next the entrance (Plan 5), adding together the measures of each side, dividing by two, and contrasting the results.

First pier: The limit of error in contrasting the north and south sides is .03.

Second pier: Error about .04, in contrasting the north and south sides.

Third pier: Error about .08, in contrasting the north and south sides.

Similar comparisons for the right nave line of piers have the following results: Limit of error; for the first pier .03; for the second pier .04; for the third pier .05.

These figures show, as regards single piers in the nave, that the variations from exact correspondence of two opposite sides may run up to .08 (line of about 17 feet). The figures also show that piers were intentionally leaned which do not lean over .10, because the uniform correspondence, as regards direction of the two sides, of piers which lean about .10 would be otherwise inexplicable. In other words it must not be concluded that a pier was meant to be perpendicular simply because it only leans .10. This would also appear from the north vestibule plumbs (Plan 14).

These figures would also show that the much larger variations between the two sides of the four particular piers which have been described at pp. 76, 77 must be intentional. It would be incredible that such correspondences of variation as are there described could be accidental inaccuracies and impossible that two sides of one pier should vary from accidental movement.

It is extremely important to observe that there are only two piers in the church having opposite sides which do not lean in the same direction. These are the two west piers of the transepts which line with the walls of the nave. The west pier in the north transept (Plan 5) has the following measures for east and west direction. The opposite sides lean together, but very slightly; .05, .10, lean east; .05, .03, lean west.

The west pier of the south transept (Plan 4) has the measures: .02, .02, lean east on the west side; .00, .00 (or perpendicular) on the east side.

Strictly speaking, only one of these piers has sides which lean together, and there are only two piers in the church whose opposite sides do not lean in one direction. The small amount of variation in the two instances is notable. For if variations of .20 or .30 were due to inaccurate construction, we should find piers in which the opposite sides would diverge, or converge, to the amount of .40 or .60. If variations of .10 were generally due to careless construction, we should find piers in which the sides would diverge, or converge, .20.

These comparisons lead to the result that practically none of the leans of St. Mark's are due to careless construction, although the variations of amount in different cases, as regards a given direction, sometimes represent variations of accuracy in the masonry. We are thus obliged to eliminate inaccurate construction as a cause of the phenomena, by a process of reasoning wholly different

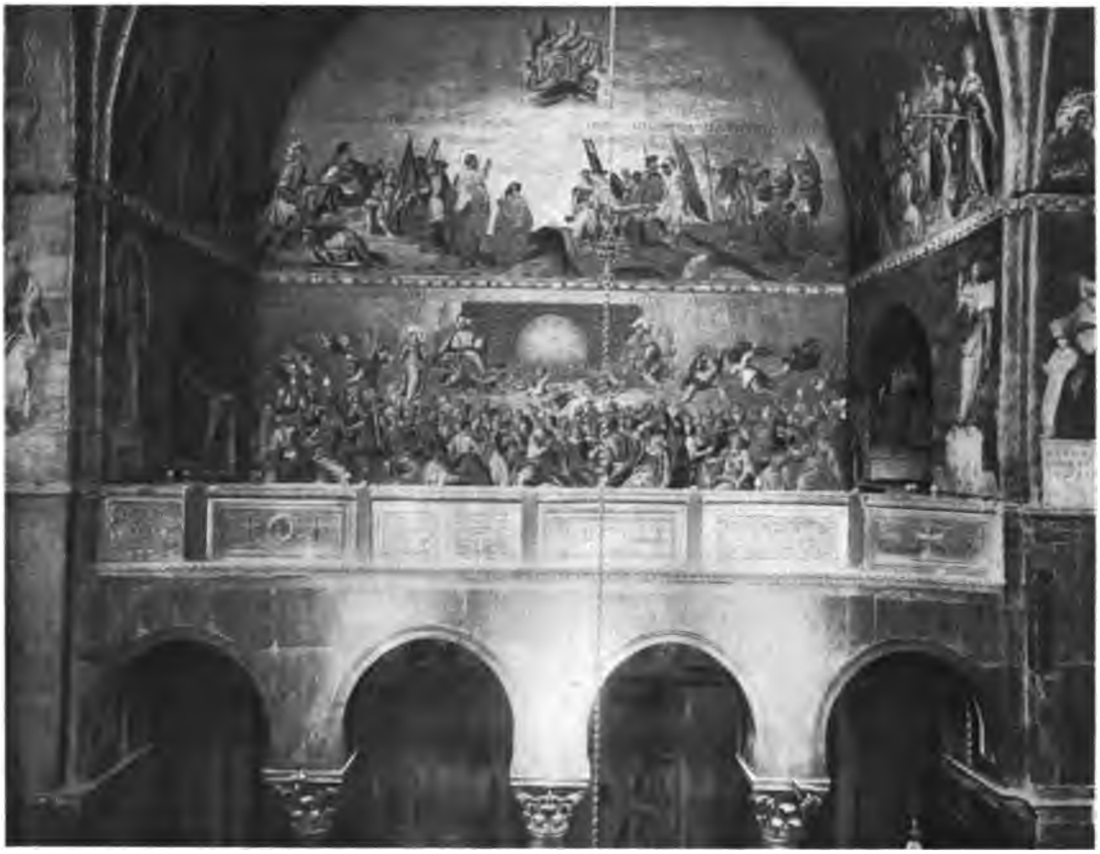


FIG. 42. ST. MARK'S. NORTH GALLERY OF THE NAVE.
From a Survey photograph of 1895. Showing the curve in elevation of the parapet. Compare Fig. 23, which also shows this curve. Similar curves are shown by Figs. 31, 34, 35.

from that which was based on the series of correspondences at remote but corresponding points. We are therefore reduced to three alternatives: systematic purpose, subsidence, or thrust, as being the cause of any particular lean.

It would be unreasonable to conceive that no accidental movements have taken place in a building as old as St. Mark's and one such movement has been mentioned in this paper (p. 56). It may be considered as proven, however, that no accidental movement has taken place, in the particular verticals which have been plumbed by this survey, of a greater amount than .15 in 15 feet, or in that ratio for greater heights. This limit of error, already established by our comparisons, may represent accidental movement, as well as the limitations of accuracy in the masonry.

Gallery Levels and Gallery Curves.

There are some apparent obliquities in elevation in the galleries, suggesting settlement, which are simply optical illusions, produced by obliquities in plan. These are translated by the eye into obliquities in elevation, which might then be naturally presumed to be owing to settlement of the piers and generally are so interpreted. For instance, in the accurate drawing from a survey photograph (Fig. 34) it is impossible for the eye not to assume a downward direction of the south gallery parapet from south to north. However, if subsidence of foundations had taken place in connection with the quoted 15½ inches lean of the end wall to the south, of course, the parapet would be oblique in the contrary direction.

As already mentioned, I have taken the levels in this gallery and found the two ends of the curving parapet to be level within .07. The appearance of obliquity in elevation is due to an obliquity in plan which is shown by the ground-plan, No. 3.

When the photograph original of Fig. 34 was made in 1895, the line of the transept wall was assumed to be the normal east and west line and the apparent obliquity of the gallery parapet is due to this error. After the obliquity in plan has been observed, it still appears to the eye to be in the east gallery rather than in the south gallery and is translated by the eye into a northward dip of the east gallery in the church itself, just as it appears in the photograph. The divergence of the east gallery from a true rectangle, as regards the south gallery, amounts to over 18 inches in 30 feet.

When the given obliquity in plan is seen above the level of the eye it produces an effect contrary to that of Fig. 34. Thus in Fig. 33 the gallery appears to go down to the right. Here again the south transept south wall was assumed as the normal line.

The parapet of the north gallery of the nave (Fig. 42) appears, to an observer in the south gallery, to dip downward in the direction of the choir. I have taken the levels between the two ends of this parapet and found it to be level within .10. Here again an obliquity of plan (see ground-plan No. 3) is partly responsible for this appearance, but, aside from the effect of obliquity in plan, all the gallery curves in St. Mark's are built with a gradual rise and a rather abrupt dip at the end of the curve.

This dip is well shown in the gallery and parapet curves which are illustrated by Figs. 31 and 34. There is a consequent appearance in the curves of being out of level and consequently an inference that they are due to settlement. It was to ascertain what might be the facts in this regard that I took the levels in the central north and south galleries of the nave and in the east and west galleries of the south transept. No obliquities in elevation were found. The limit of variation from a true level was nowhere over .10.

The two short galleries next the gallery over the west vestibule have marked obliquities in elevation (Fig. 43), but as soon as we notice that one side of the arch is longer than the other, it is evident that they are not due to settlement. The drop of the short south gallery was found by level to be about .40.

These notes bear in two directions. They draw attention to the construction of the horizontal curves in elevation, which are mentioned in Commendatore Saccardo's certificate and they tend to show that the accidental movements in St. Mark's have not been of an important character.

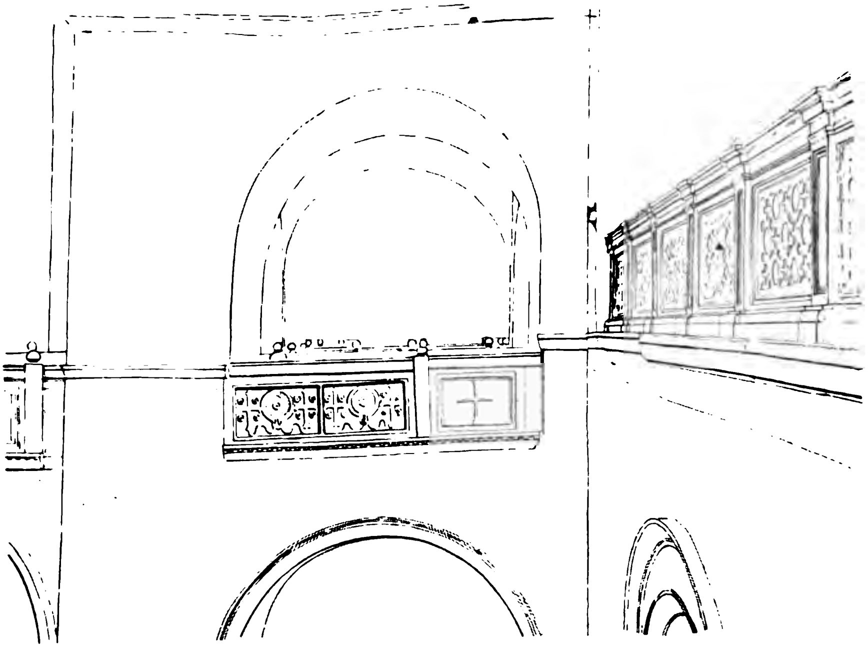


FIG. 43. ST. MARK'S SOUTH SHORT GALLERY OF THE NAVE.

Tracing from a Survey enlargement of 1901. The gallery is oblique .40, by construction. The north short gallery of the nave has the same obliquity.

The general problem of the horizontal curves in St. Mark's is so bound up with the problem in other Italian churches and cloisters that we must dismiss the subject here, as far as the question of intention is concerned, with a reference to the verdict of Saccardo and with the remark that the existence of constructive curves in mediæval Italian architecture has been decisively proven for other buildings.*

---

*Architectural Record, Vol. VI., No. 4, 1897; Journal of the Archæological Institute of America, Vol. VI., No 2 (New Series), 1902. The latter publication contains a certificate from the engineering architect in charge of the Pisa Cathedral for the curves in that building, which is also published in Vol. I., No. 1,of these Memoirs

Horizontal curves in elevation are found in the main north and south galleries of the nave (Fig. 42); in the east and west galleries of the south transept (Figs. 34, 35); and in the east gallery of the north transept (Fig. 31). The west gallery of the north transept has no curve. There are also curves in plan in the transept end galleries. The careful cutting and fitting of the casing which is connected with the curves in elevation is shown by the half-tones,

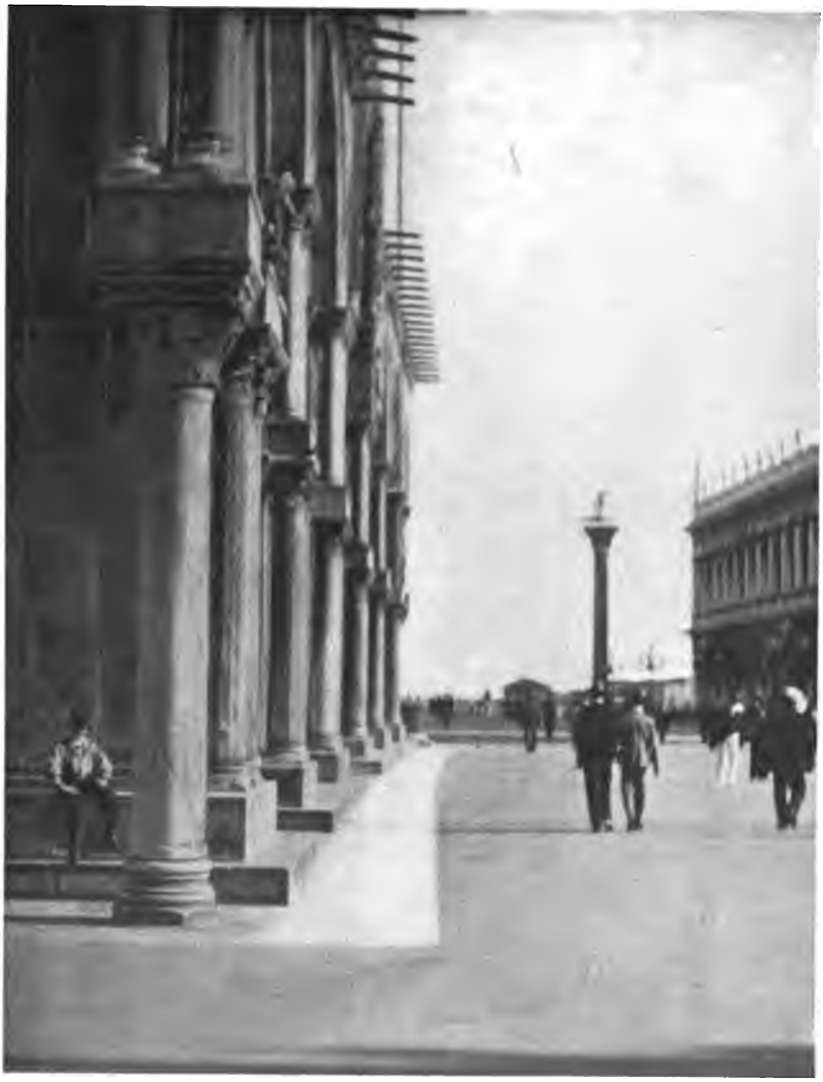


FIG. 44. ST. MARK'S FAÇADE.

From a Survey photograph of 1901. Showing the bend or curve in plan, concave to the Piazza. The amount of curve is 10 inches.

Figs. 31 and 42, and has been accurately reproduced in the drawings which were made for Figs. 34, 35. It is clear, if these curves had been due to settlement, that the casing must have been laid on after the settlement had ended. It would be absurd to suppose that any such series of uniform movements in all parts of the church had uniformly antedated the period of the casing.

Fig. 44 shows the curve in plan of St. Mark's façade which is mentioned as an æsthetic device in Signor Saccardo's letter. This curve was measured in 1895 as having ten inches deflection. An illustration was published in the Architectural Record, Vol. VI., No. 4, 1897; p. 489.

As regards the obliquities in the short galleries of the nave which have been mentioned (Fig. 43) they may be, and probably are, related in purpose, to obliquities in the Pisa Cathedral which have been published and which have been verified as constructive by the architect in charge of the Cathedral.[*]

The Pavement of St. Mark's.

Many depressions in the pavement of St. Mark's are obviously due to accidental causes. One change of level in the pavement of the church is certainly constructive. This is a gradual upward slope from entrance to choir, amounting to 7½ inches (survey of 1895). Inasmuch as eighty-five churches in Italy have been observed to have a constructive slope in the rising direction, from entrance to choir, there is no doubt that this instance is constructive.[†]

There is no reason why the rises in the transept pavement toward the choir should not be of the same class. The fact that the transept galleries are found to be level as far as tested (no levels were taken in the north transept) indicates that these pavement slopes are also constructive. If change of level in the transept pavement were due to subsidence the galleries would be out of level.

As regards the great rising curve of the pavement across the nave, which is especially strong near the choir, no expert should venture an opinion before examining the pavement of S. Donato at Murano. The ancient pavement, in opus Alexandrinum, of this church, has a rising curve across the nave of a very marked amount which is certainly constructive. This may be the first published mention regarding this curving pavement, although it has been noticed by more than one observer. The English architect Street was the first to announce that certain main undulations in the pavement of St. Mark's are constructive.[‡] These undulations have undoubtedly contributed to the general oversight of the fact that the leaning verticals of St. Mark's are intentional.

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[*] Memoirs of the Museum, Vol. I., No. 1, and Journal of the Archæological Institute of America, Vol. VI., No. 2, New Series.

[†] Architectural Record, Vol. VI., No. 2; 1896.

[‡] Brick and Marble in the Middle Ages, p. 150.

As regards the questions which are raised by the pavement of St. Mark's it maybe added that most instructive remarks on the science of piling as practiced in Venice, have been published by Mr. C. H. Blackall, an architect of Boston.* In 1885, when Signor Boni was in charge of St. Mark's, Mr. Blackall was able, with his co-operation, to undertake the necessary excavations and to make an exhaustive examination of the piling of the Campanile. It was proven by this examination that "the foundations have stood the test for centuries without moving an inch."

In the 16th century Vasari mentioned in his Life of Arnolfo di Cambio, that the Campanile of St. Mark's "has never sunk, even by a hair's breadth."

The weight of the Campanile is estimated by Mr. Blackall at about 13,000 tons. The piers of St. Mark's have individually only a fraction of such a weight to support and there is no cause to suppose that they were less carefully founded. The special causes which led to the downfall of the Campanile have been mentioned by Signor Saccardo, in the Architectural Record, Vol. XII., No. 7, 1902.

From these various considerations we should again conclude that the accidental movements in St. Mark's have not been very important. These considerations were all mentioned in the "Echo from Evelyn's Diary," but for casual or inattentive observers the phenomena which have been described tend to suggest accidental movement by thrust and subsidence. It was on this account that the opinion of Signor Saccardo, who is so thoroughly familiar with the piling and foundations of the church, was so especially desired, and it is on this account that the corroborations of this opinion, which were subsequently obtained, have been carefully narrated.

The Question of Repairs.

One main purpose of this publication is to forestall the farther obliteration of the architectural refinements of St. Mark's, which had assumed alarming proportions under the predecessors of Signor Boni and Signor Saccardo.

The fall of the Campanile (which itself had a northward lean, not due to settlement†) is destined to awaken doubts as to the stability of other ancient buildings and it is destined to draw attention to all leaning verticals in the ancient monuments and to awaken consequent suspicion as to their stability.

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*"American Architect" for August 29th, 1885.

†See the quoted article by Mr. Blackall.

The importance of calling the attention of the Italian authorities, of all European governments, and of all experts in charge of ancient buildings, to the facts which are herewith published is sufficiently obvious. The phenomena of the spread or widening are certainly not confined to Italy and they are certainly to be found there in many churches, aside from those described in this Memoir.

The danger that authorities in charge of repairs may innocently destroy important features of architectural refinement is sufficiently apparent. St. Mark's, especially, should be handled as carefully as a canvas of Titian or a statue by Praxiteles. It may be not less aptly compared to a piece of old lace as regards the care which should be given it.

That the danger is not imaginary is shown by the announcement in these Memoirs, Vol. I., No. 1, that the lower line of columns on St. Mark's façade has a constructive forward lean (as mentioned in Saccardo's certificate) and by the fact that the columns at the southwest angle of the façade have been reset in a perpendicular position by the modern repairs of that angle. The incorrect resetting of the pinnacles and statues of the north and south façades has been mentioned in Saccardo's letter. It also appears probable that the evidence for a widening in the west vestibule has been destroyed by a resetting of the columns.

Although most of the churches in Northern Europe, and a certain number in Italy, have still to be examined as regards the existence of this remarkable refinement of widening the vertical lines in the rising direction, it is safe to predict that no other church will be found to show so consistent and far-reaching an application of it as St. Mark's. It is also true that this church is peculiarly exposed to the obliteration of the evidence, through repairs of the casing and the resetting of columns and through the natural presumption that accidental movements are responsible for the deflected verticals.

Purpose of the Widening.

The discussion of the purposes of this refinement has been avoided in this paper, as involving a possible element of debate, of uncertainty, or of difference of opinion; and because, the important thing at present is to establish the facts and to induce experts to consider the resulting effects in the given churches, and especially in St. Mark's.

The ultimate explanation of any such refinement must be that it appeared to the builders an improvement, as against other churches which did not possess it. The ultimate essence of this improvement may probably lie in the feeling which leads us to prefer a free-hand drawing to a mechanically executed architectural elevation or architectural section. That the widening effect is an improvement in St. Mark's, as against churches which do not possess it, is indubitable in the opinion of the writer.

To an age which has been thoroughly satisfied, for three or four centuries, with absolutely rectilinear buildings, with mathematically accurate measurements of construction, and with absolutely symmetrical correspondences in all architectural members and features; which has even exalted these things as an ideal of perfection in building; the whole subject of architectural refinements is a matter of difficult apprehension. It is probable, however, that no artist who compares a rectified and schematic drawing of any portion of St. Mark's with a survey drawing or photograph for the corresponding view, will hesitate to prefer the latter. For example, let Fig. 20 be conceived as rectified and corrected into a drawing with straight and rigid upright lines and it will obviously lose charm and beauty. No other explanation seems really necessary.

Nothing has been said, so far, of the fact that the great side arches of the nave also recede outward, in continuation of the vertical inclination of the walls below (Fig. 20). This is a very essential feature, and probably the most important element, in the general effect of this device. If some attention be given to this detail it will probably be of material assistance to an appreciation of this refinement.

In the case of St. Mark's there is no doubt that the effect of spaciousness in the upper portion of the church is much enhanced by the given device. It is also clear that the graceful bend of the verticals (for instance, in Fig. 25) is preferable to the rigidity of the straight line. The real question at stake is whether we have not a demonstration in such devices of the formalism and decadence of modern architectural taste. The most significant fact is probably the one that we have to labor for an explanation. It is quite certain that those who are best aware of the admitted deficiencies of modern architecture will be most sensitive to the beauties which are undoubtedly inherent in this refinement.

The fact that vertical curves of a very delicate character have been discovered by the writer in other churches is undoubtedly in point. The fact that vertical bends have been found at Cremona and Pisa, of a somewhat different character, should not be overlooked.

It is also probable that a careful discussion of the vertical bends of St. Mark's would involve giving a less summary consideration to the horizontal curves of this church than they have received in this paper.

The refinement of forward leaning and bending verticals on the façade of this church has been discussed in the preceding Memoir and has also its bearing here on the general question. So have those refinements in the setting of the pinnacles and statues of the façade which were discovered by Signor Saccardo.

Various other architectural refinements of mediæval Italian architecture which have been elsewhere published by the writer, have a bearing on the general question. So also have those preliminary observations of Mr. Ruskin which preceded all others in this direction, as far as mediæval building is concerned.[*]

If all these various devices be interpreted to demonstrate a profound distaste for formal and rigid architecture, it becomes easier to comprehend the widening of the verticals. Contrariwise it will be difficult to conceive that the widening and bending of the verticals was intentional without giving serious thought to the significance of the horizontal curves.[†]

A peculiarly interesting problem is offered by the leaning walls at the north and south extremities of the transepts. In this instance a widening effect pure and simple can hardly be in question. The north and south widening does not continue above the parapets to any marked degree and the faces of the walls which continue the vertical lines of the pilasters of these walls are either perpendicular, or bend toward the perpendicular, above the level of the parapets. It is difficult to suppose that a widening effect could be attempted by a device which does not widen above. In the second place these walls are, for the most part, seen in face. It would be impossible, moreover, in view of the distance between the transept walls, for the eye to include them in one view. It may be conceived that the widening in the nave would logically carry with it a parallel treatment in the supports and surfaces of the transepts, but it is questionable whether this motive would suffice to explain the additional amount of inclination. On the other hand, if the bend of the entire line, rather than the lean of a part of it, be considered, we find a motive which unites with that which must probably be ascribed to the horizontal curves and to the obliquities in elevation.

The refinements of St. Mark's have peculiar significance, on account of the rough, and to modern ways of thinking, frequently careless, workmanship in this church. No other important church in Italy is so roughly built in certain particulars. It is such workmanship, especially as shown in the use of heterogenous materials, which has given our modern critics the impression that mediæval builders were incapable of subtleties. It is, no doubt, difficult for modern taste to understand the co-existence of offhand indifference to formal regularity with the carefully planned construction of intentional subtleties. But it must now be admitted that these things did co-exist.

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[*] Seven Lamps of Architecture: "The Lamp of Life." A list of publications by the writer, on architectural refinements, is given on the third page of the cover.

[†] The excellent article on "Refinements," by Mr. G. L. Heins, in the Dictionary of Architecture, which has been edited by Mr. Russell Sturgis (Macmillan) offers a solid basis for future discussion.

Outside of the buildings themselves, any satisfactory study of the phenomena, and of their purpose, must be made with the assistance of enlarged photographs. Illustrations of the size employed in this paper can hardly be considered as satisfactory, on account of the reduction of dimensions. The Brooklyn Institute Museum is, at present, the only centre in which such enlarged photographs are exhibited. It is believed that the importance of the facts which are illustrated by them is such as to make similar enlargements of value also to other institutions of learning. All of the drawings and half-tones which are mentioned in the titles of the illustrations as reproducing survey photographs, represent negatives which have furnished very satisfactory enlargements, with two exceptions. Many have the unusual dimensions of 25 x 35 inches.[*] It is hardly necessary to say that the drawings which are published, have been made with scrupulous fidelity, over tracings from the photographs. All of these drawings have been made by Mr. Herbert B. Judy of the Museum staff, with a few exceptions which were drawn or traced by Mr. McKecknie for the earlier Architectural Record publication.[†] The survey photographs, which are dated by the captions of 1895, were all made by Mr. McKecknie under direction of the writer. All photographs which are dated to 1901 were made by the writer.

Disappearance of the Tradition.

The problem offered by the disappearance of mediæval architectural refinements, without a survival of record or tradition regarding them has been elsewhere considered by the writer.[‡] It has been elsewhere shown that the number of Italian churches which exhibit architectural refinements is much smaller in the late Italian Gothic than in earlier periods and that these refinements dwindle very decidedly in amount and in variety, as the Renaissance period approaches. On the other hand, although it was undoubtedly the Renaissance which led to the abandonment of these refinements, the surveys of the Brooklyn Institute Museum have recently discovered very interesting instances of isolated Renaissance survivals of them. One of great importance has still to be published. Another was published in the last Memoir, and in the present paper we have the instance of S. Giorgio Maggiore at Venice.

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[*] The exceptions are Figs. 26 and 34, but the right aisle is also represented by an excellent unpublished enlargement, taken without the plumb-line. The illustrations which represent enlargements of size 25 x 35 inches are named on the second page of the cover. The Museum exhibit includes many unpublished enlargements of great importance.

[†] The following drawings and tracings were made by Mr. McKecknie: Figs. 3, 9, 21, 22.

[‡] Especially in the Architectural Record, Vol. VII., No. 1, "A Discovery of the Entasis in Mediæval Italian Architecture." 1897, and in these Memoirs, Vol. I., No. 1, "A Renaissance Leaning Façade at Genoa."

It is hardly necessary to re-emphasize the significant fact that a refinement was practiced as recently as the time of Palladio, of which only one literary record has survived, and that record made by a man who did not himself agree with the two architects who believed that the main building of the old St. Paul's "receded outwards" for an optical reason. The disappearance of tradition, regarding the mediæval refinements shows that we have much to learn as historians. We are more than familiar with the overthrow and disappearance of classic ancient culture in early mediæval Europe, but we are less disposed to realize the overthrow and disappearance of the mediæval culture which was effected by the Renaissance.

The isolated case of Renaissance survival which was shown for mediæval leaning façades in the preceding Memoir, is here paralleled by an isolated case of Renaissance survival for the widening or spread. It may possibly be found in other Renaissance churches, but it is quite certain that it will not be found in many.

It is probable, on the other hand, that a very considerable number of mediæval instances remain to be noticed in Italy alone. It is also certain that a very large number of Italian Mediæval churches and cathedrals, and many which show other refinements, do not show this one.

No solid foundation for the study of mediæval architectural refinements can be laid without systematic publication of the cathedrals and churches which are destitute of refinements. Generally speaking, matters are in shape for such a publication, on the part of the Brooklyn Institute Survey, in the case of the Italian peninsula, as far as all the well known and generally quoted monuments are concerned. My experience has, however, led me to the conclusion that no refinement so easily escapes notice as the widening refinement, and I am inclined to believe that it may have been overlooked by our examination in some instances. It may simply be said that all the well known churches of Italy, and many which are not well known, have been examined and that all known cases in Italy have been mentioned. Some known instances in northern Europe are reserved.

Since there is no church in Italy in which this refinement is so widely and carefully applied as St. Mark's at Venice, the probabilities are at present that a Byzantine subtlety is originally in question, but farther researches in the original centres of Byzantine building must be made, before this can be considered as more than a probability. Nothing of the kind has been noticed in S. Vitale at Ravenna or in S. Ciriaco at Ancona.

The presence of this particular refinement in some churches, when considered in connection with its absence in others, shows either that the tradition was limited to certain masonic guilds or that it was limited to an esoteric knowledge, possessed and handed down by individual architects or master masons. Motives of economy may explain the omission in some cases.

The given refinement has not been found in the large class of Italian timber-roofed columnar basilicas, of which the Pisa Cathedral is the most famous example, although it is found, as mentioned (p. 27), in the nave arch of the timber-roofed Cathedral of Trani and in the apse arch of the timber-roofed Capella Palatina at Palermo. Santa Maria della Pieve at Arezzo was also originally a timber-roofed building and, although it was vaulted by Vasari, it has been restored to its original form. It has, however, pier supports and has other relations to Lombard and northern architecture.

In conclusion it should not be overlooked that the world of archæology is much indebted to Mr. and Mrs. August Lewis, of New York, and to the Trustees of the Brooklyn Institute Museum, for their encouragement and support of these surveys.

Museum of the Brooklyn Institute of Arts and Sciences,
Dec., 1902.

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Vol. I: No. 4.

VERTICAL CURVES AND OTHER ARCHITECTURAL REFINEMENTS

IN THE

GOTHIC CATHEDRALS AND CHURCHES

OF NORTHERN FRANCE

AND IN

EARLY BYZANTINE CHURCHES

AT CONSTANTINOPLE

AN ACCOUNT OF OBSERVATIONS DURING THE SUMMER OF 1903; WITH A DESCRIPTIVE LIST OF THE PHOTOGRAPHS OF SURVEY

BY

WILLIAM HENRY GOODYEAR

Curator of Fine Arts in the Brooklyn Museum. Author of "A History of Art;" "The Grammar of the Lotus;" "Roman and Mediæval Art;" "Renaissance and Modern Art."

WITH THIRTY-ONE ILLUSTRATIONS

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ARCHITECTURAL REFINEMENTS
IN FRENCH GOTHIC CATHEDRALS AND EARLY BYZANTINE CHURCHES.

Preface.

During the first and second quarters of the Nineteenth Century it was observed that the temples of the ancient Greeks exhibited a variety of intentionally constructed deviations from the exact symmetry and geometrical regularity which had been presumed by the earlier students and imitators of these monuments to be present in them. Straight lines, true perpendiculars, equidistant spacings, and uniformity of dimensions in corresponding parts, were found to have been generally avoided in Greek architecture.

In 1849 ("Stones of Venice"), and in 1851 ("Seven Lamps of Architecture"), Mr. Ruskin published observations, at Venice and at Pisa, of intentional variations from regularity in the dimensions of arcades and of intercolumnar spacings. His philosophy of these variations in the "Lamp of Life" is a profound and brilliant contribution to the subject.

In 1874 the author of this Memoir published observations and measurements of constructed bends, leans, obliquities, and curves in the lines and surfaces of the Pisa Cathedral and announced the probability of a relationship of purpose, and of a historical connection as regards derivation, between these phenomena and those which had been found in the Greek temples.

In 1895 the writer was employed by the Brooklyn Institute of Arts and Sciences to make a general examination of the cathedrals and churches of Italy, in order to ascertain whether the phenomena which had been observed at Pisa might be found elsewhere. A bibliography of publications describing some of the results of this examination will be found on the second page of the cover.

In consequence of these publications a continuation of this research in Italy was undertaken in 1901, and several publications were made regarding it. An important feature of the research was the making of photographic negatives and the preparation of cartoons of survey, to verify and illustrate the existence of various refinements of construction.

In the summer of 1903, this research was extended to Northern France and to the Byzantine churches at Constantinople.

The exhibit of photographs which is described by this Memoir is confined to the photographic series of 1903. The original negatives of this series amount to some 330 in number, of which 126 have been selected for enlargement (86 of size twenty-five

Brooklyn Institute Museum (6-17-17)

inches by thirty-five inches and 40 of size eighteen inches by twenty-two inches). The entire number of negatives available for enlargement in this series is two hundred and seventy, of which one hundred and sixty are available for enlargement to twenty-five inches by thirty-five inches, and one hundred and ten are available for enlargement to eighteen inches by twenty-two inches.

The exhibited photographs of the series of 1903 are largely devoted to a system of architectural refinements which employs a vertical curve or bend in place of the normal perpendicular. Many of these vertical curves and bends are so constructed as to produce a widening in the upper portion of the nave. In some instances the piers of the nave diverge in the upward direction in lines which do not curve. In other instances the outer piers or walls of the side aisles lean outward, in straight lines, to produce a widening, whereas the verticals of the nave lean outward in bends or curves.

For a philosophy of the vertical curves and bends and of the "widening refinement" reference is made to Vol. I., No. 2, of these Memoirs of Art and Archæology.* This publication also includes an account of the development of this particular branch of the investigation, as far as the Italian churches are concerned.

Arrangement of the Exhibited Photographs.

Whereas the majority of the churches so far examined in France belong to the latest period of mediæval architecture, viz: the Gothic, and whereas many of the churches in Italy, which exhibit the vertical bends, or curves, belong to the earlier Romanesque period, the recent observations at Constantinople have had the great importance of demonstrating the existence of this refinement in Býzantine architecture of the Sixth Century. Hence an arrangement of the photographs which places first those from Constantinople, beginning with St. Mary Diaconissa, dating 599 A. D. This church is now a mosque, known as Kalender Khâneh Jami, and is situated south of the eastern end of the Aqueduct of Valens.

ST. MARY DIACONISSA, CONSTANTINOPLE.

1 View of the widening, from the choir, looking toward the entrance. Plumb-lines are suspended on either side. Surveyor's rod to right of centre.† Approximate width between piers at the

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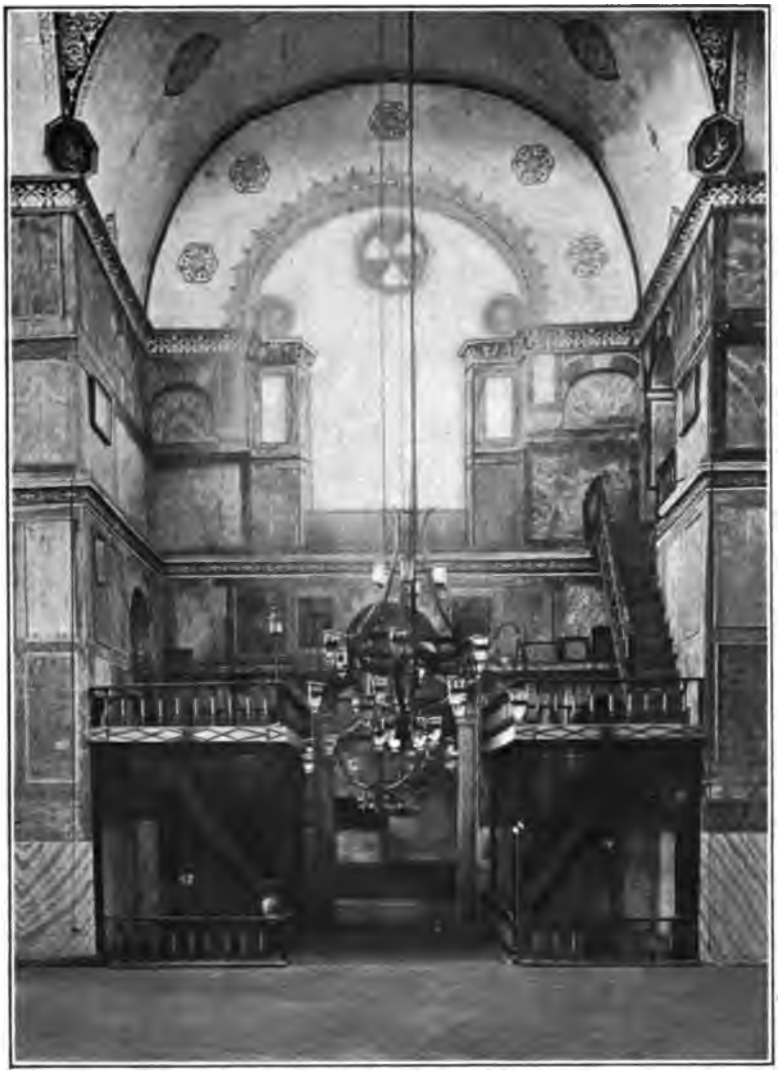
*"The Architectural Refinements of St. Mark's at Venice; with remarks on other Churches showing a similar system of Leaning Verticals, especially those in Orvieto, Vicenza, Milan, Pavia, Bologna, and Arezzo, and including the Renaissance Church of S. Giorgio Maggiore at Venice." Published by the Macmillan Company for the Brooklyn Institite of Arts and Sciences.

†Having a height of 6 feet, with a disk 5½ inches wide. The rod offers a convenient means of verifying or establishing measurements on the same plane in the photograph. The same rod is used in all other pictures which are described by this list, and will be mentioned occasionally, lest it be overlooked.

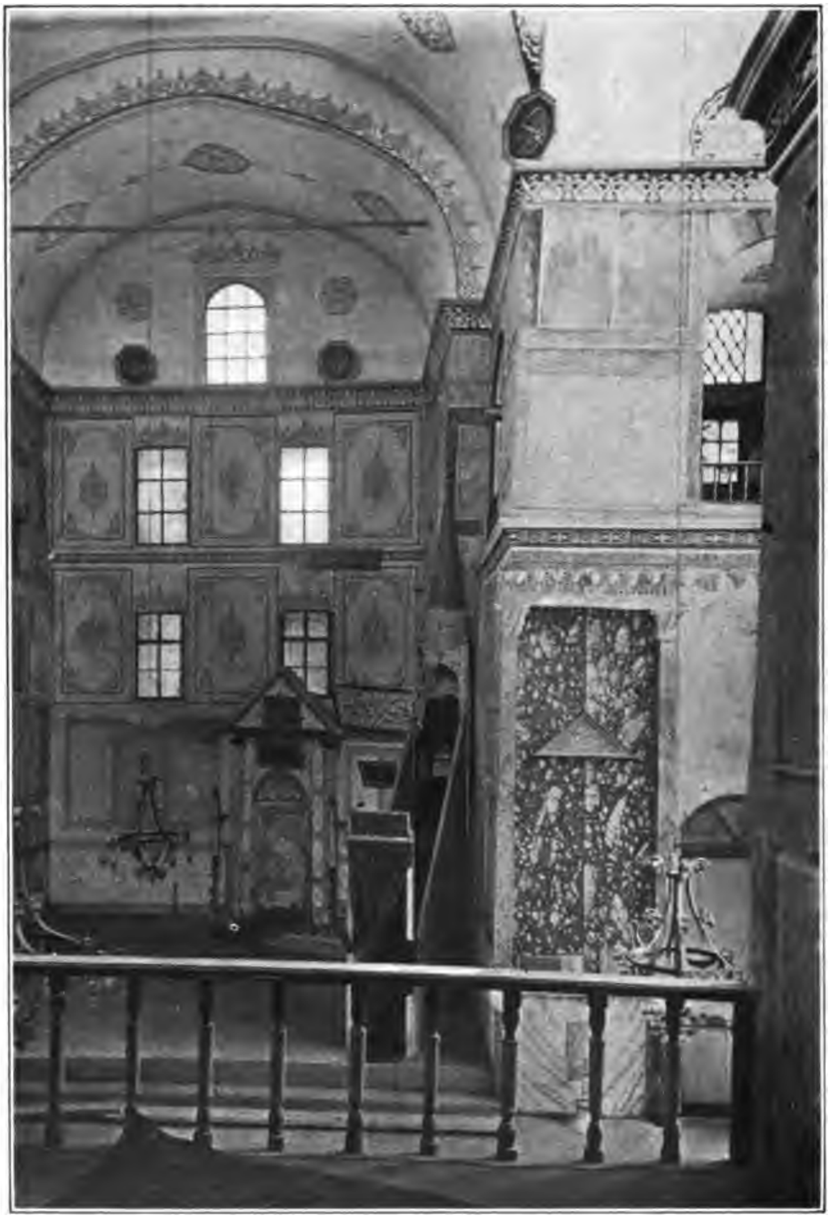


1. ST. MARY DIACONISSA, CONSTANTINOPLE.

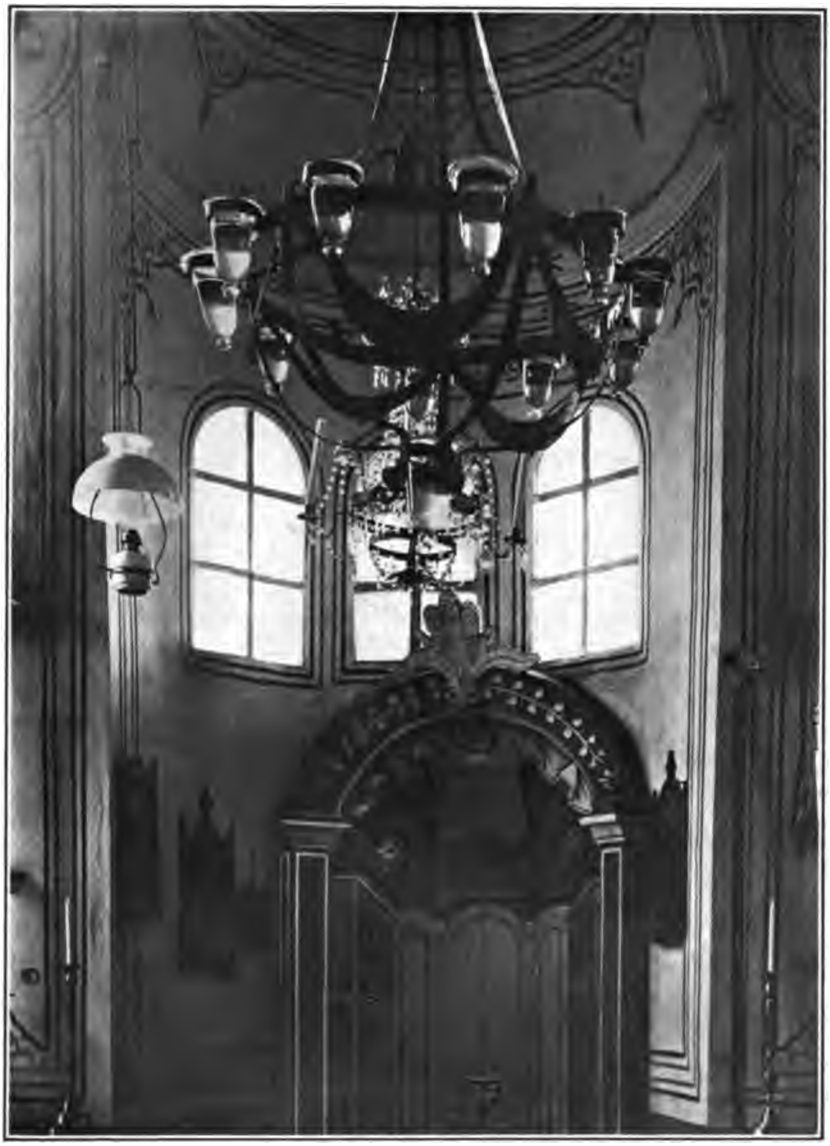
pavement twenty-five feet six inches. The widening at the springing of the vaulting is sixteen inches, in a height of thirty-three feet.

2 Detail of No. 1, showing plumb-line and surveyor's rod.

3 Views from the right gallery (left in No. 1), looking toward
4 the choir. These views show very pronounced vertical bends. On the side photographed, the bend has a deflection from the perpendicular of eleven and a half inches in thirty-three feet but is less on the side opposite. The perpendiculars are established by



3. ST. MARY DIACONISSA, CONSTANTINOPLE. FROM THE GALLERY, LOOKING TOWARD THE CHOIR.



5. APSE, BALABAN AGA MESJID, CONSTANTINOPLE.

the lamp-chains and by a plumb-line which is seen to be suspended, in No. 3, in the angle between the wall and the pulpit.

This church has the form of the Greek cross and there are corresponding vertical bends in the transept arms, which intersect those shown by the photographs. For similar intersecting bends in St. Mark's at Venice, see Memoir No. 2, as quoted. For intersecting bends and curves in French churches see later numbers of this series, especially those from St. Remi at Rheims (20, 21), from St. Quentin (41, 42) and from Amiens (43, 44).

BALABAN AGA MESJID, CONSTANTINOPLE.

5 Apse of a small Byzantine church, undated and situated north of the ruins of the Aqueduct of Valens. View showing the widening refinement. Width of apse at the pavement, seven feet; width at the springing of the arch, seven feet five and a half inches. Widening, five and a half inches in a height of twelve feet. A short plumb-line hanging from a nail on the right establishes the perpendicular; surveyor's rod on the right. There is no other widening in this church, which resembles the minor Coptic churches of Cairo. An extremely important photograph, as showing a Byzantine preference, from a decorative or æsthetic point of view, for lines which widen toward the springing of the arch. This is the only known Byzantine instance of the widening, out of four at Constantinople, in which the verticals do not bend. Hence the bend (or curve) and the widening must have been regarded as independently preferable, although they were generally combined. As the height of this apse is only twelve feet to the springing of the arch, it also appears that the correcting of a convergence due to perspective cannot have been the purpose here. This again shows that the widening was considered as an æsthetic improvement aside from its possible use in large churches to correct perspective convergence and consequent appearance of narrowing in. Another instance proving that a decorative or æsthetic preference was one of the motives for the widening is found in the central arch of the upper portico of the façade of S. Ambrogio at Milan (Memoir No. 2, Figure 9).

No. 5 shows the vertical inclination to be strongest on the right side. This is a very frequent appearance. Notable instances of this same appearance are St. Mark's at Venice, Sta. Maria della Pieve at Arezzo, Notre Dame at Paris, St. Loup at Chalons, and St. Mary Diaconissa (choir end).

Among other churches in which the widening is limited to the apse or choir, are the Capella Palatina, Palermo, the church of St. Radegonde at Poitiers, and the Schottenkirche at Vienna (late 17th century Renaissance).

CHURCH OF THE MONASTERY OF THE CHORAH, CONSTANTINOPLE.

Dating from the Eleventh and Twelfth Centuries, now known as the Kahriyeh Jami and famous for its remarkable mosaics. This church is quoted by Fergusson and other authorities as having probably furnished the suggestion for the style of the primitive façade of St. Mark's.

6 View of the choir. Width of the apse at the pavement twenty feet. The widening is nine inches in a height of twenty-one and a half feet. There is an obvious analogy here with the form of the horse-shoe arch, as most of the widening is obtained by a rapid recession in the four horizontal bands of casing under the arch.

The walls of the nave (faced with marble) lean off to right and left as in St. Mark's at Venice. There are also transverse leans in the transept walls.

Sta. Sophia, Constantinople.

The most important instance of the widening and vertical bends at Constantinople is found in Sta. Sophia, but permission could not be obtained from the authorities for photography.* The bends are concealed by the large shields containing the names of the companions of Mohammed which have been suspended in the angles of the mosque. The best position for sighting the bends is one taken behind the shields. Excellent photographs of them might be obtained from such positions. The large photographs of Sta. Sophia which are sold by the Constantinople photographer, Sebah, and which are pieced together from six separate photographs, do not show the widening, because the sections have been trimmed and fitted together so as to conceal it. The statement was personally made to the author by Mr. Sebah that he had considered the obliquities to be defects in the photographs. He subsequently examined the church with me and was deeply interested in verifying with me the existence of the vertical bends. In view of my inability to procure permits from the authorities Mr. Sebah was willing to make photographs from special points of view selected in his company. Mr. Sebah is, however, not allowed at present to take photographs in Sta. Sophia and it was not possible last Summer, nor has it been possible since that time, for the author to make use of this acquaintance for the procuring of photographs of the bends.

The lack of photographs from St. Sophia is more especially to be regretted because the string courses of the side galleries exhibit strong horizontal curves in plan, convex to the nave, of about twelve inches in amount. These curves are similar to those of the Pisa Cathedral and some other Italian churches and are undoubtedly constructive. Horizontal curves were not found in any other of the Constantinople churches. They have already been dated to the Sixth Century in S. Apollinare Nuovo at Ravenna by the observation of 1895 (Arch. Rec., Vol. VI., No. 4).

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*To be strictly accurate, however, permission was accorded by the First Secretary of the Sultan, Tahsin Pacha, who is the supreme authority of the Turkish state, in such matters. The necessary advices were not however forwarded from the Palace to the Ministry of Mosques and no efforts could secure the carrying out of this necessary formality, during two weeks' stay in Constantinople. Acting under instructions from Mr. Leishman, the American Minister, the First Dragoman of the American Legation, made two calls at the Palace in order to obtain the permission, and I was personally present at one of the interviews with Tahsin Pacha, in which the permission was accorded.

That the horizontal curves of Sta. Sophia are derived from those of classic antiquity may be regarded as a positive certainty and Byzantine derivation for the mediæval horizontal curves must also now be conceded. The most important publication so far made for mediæval horizontal curves is that in Vol. VI., No. 2, of the Journal of the Archæological Institute of America. This is the only extant publication in which the curves of the cloister of the Celestines at Bologna and in the cloister of S. Zeno at Verona, have been illustrated.

The church of Ss. Sergius and Bacchus has no widening and no vertical bends. The church of St. Irene is used as a Turkish armory and could not be examined.

The widening of Sta. Sophia is mentioned by the contemporary author, Procopius. In Lethaby and Swainson's work on Sta. Sophia the following passage occurs on page 25, in the translation of the description which Procopius gives of the interior:—"The building rises from the ground not in a straight line, but setting back somewhat obliquely."

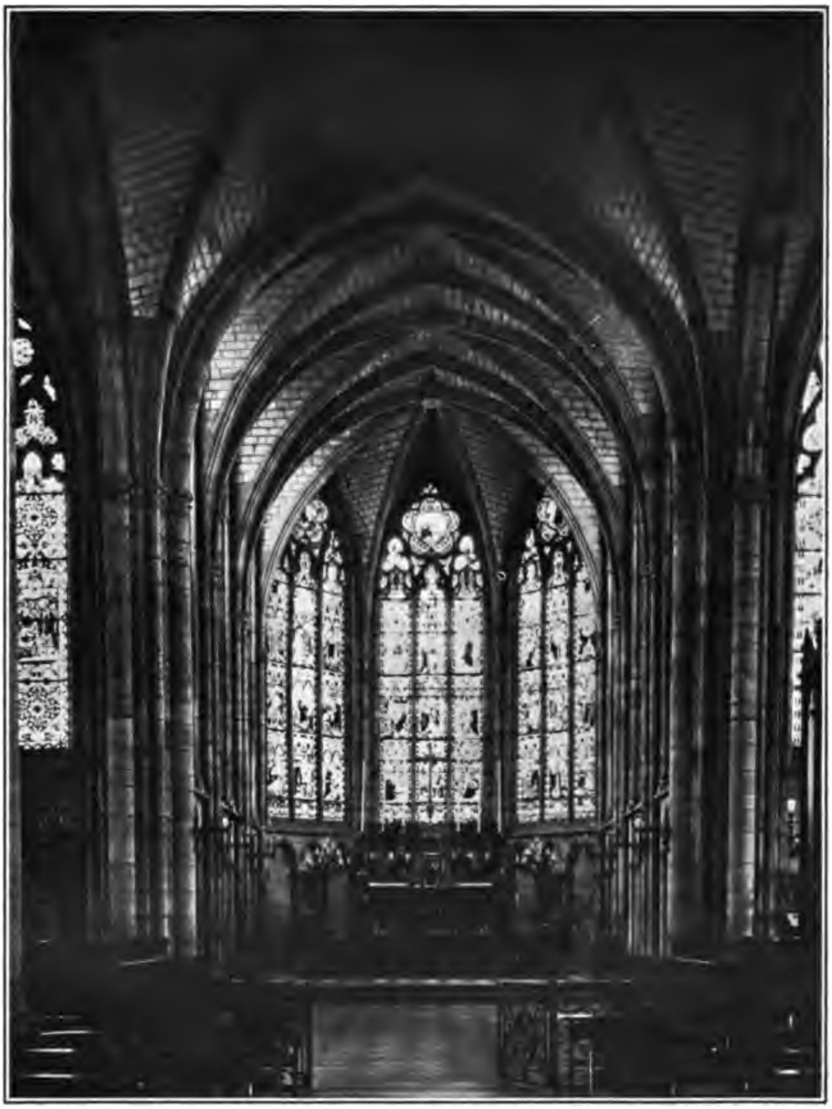
Vertical Curves and Bends in the Romanesque.

As the vertical bends are more systematically and extensively employed in St. Mark's at Venice, than in any other church in Europe (the details of the intersecting systems are developed with incredible ingenuity and elaboration in that church, as shown in Memoir No. 2), it is now positive, in view of the observations at Constantinople, that the vertical bends and widening in later mediæval architecture have a Byzantine origin.

As regards the Romanesque period in Europe reference must be made for the present to the publication above quoted for the Romanesque in Italy. In France the observations have been so far mainly limited to the Gothic; by reason of the fact that the localities visited were mainly in Northern France and almost wholly such as do not contain Romanesque churches.

Plan of Arrangement for France.

No observations outside of France were made in Western Europe in 1903, with the exception of those in Strassburg and Vienna. The order of arrangement of the photographs from French localities is controlled mainly by the wish to place first those which offer the most remarkable evidence of intentional construction. The views from Notre Dame at Paris are placed among the last,



8. THE CHOIR, ST. LOUP, CHALONS.

because they represent many remarkable features which are wholly distinct from the vertical curvature and the widening.

ST. LOUP. CHALONS. Nos. 7-11.

7 Views of the Nave. In No. 7, lamp-chain plumb-line, and sur-
8 veyor's rod right of entrance to the choir. In No. 8 the plumb-line hangs from a nail on the right side of the right pier, close to the window. Width between piers at the choir twenty-four feet. Amount of widening at the choir thirteen inches in a height of

9. THE RIGHT AISLE, ST. LOUP, CHALONS.

thirty-two feet. The most pronounced lean is on the right side (see No. 5). St. Loup is a rare instance of a church in which the piers of the nave diverge outward in straight lines, with leans beginning at the pavement. The churches of St. Thomas at Strassburg and of the monastery of Montierneuf at Poitiers are other instances in France (Nos. 12, 13, 127-129). Churches of this class in Italy are S. Ambrogio, Milan; the Cathedral of Perugia and Sta. Maria della Pieve at Arezzo (Memoir No. 2).

Portions of the windows at the ends of the aisles are visible in this view. These windows abut directly against the leaning piers of the choir and lean off with them to right and left. The following view shows the window of the right aisle in which the leaning construction is most pronounced.

9 Window of the right aisle built with leaning mullions. These mullions are set obliquely with reference to the base of the window, which is set level. A plumb-line is suspended from a nail to the right of the window. (The pole by which the tape has been lifted to the nail is also leaning against it.) The pilaster to right of the plumb-line leans off about seven inches in twenty-four feet. Surveyor's rod placed horizontally on the altar.

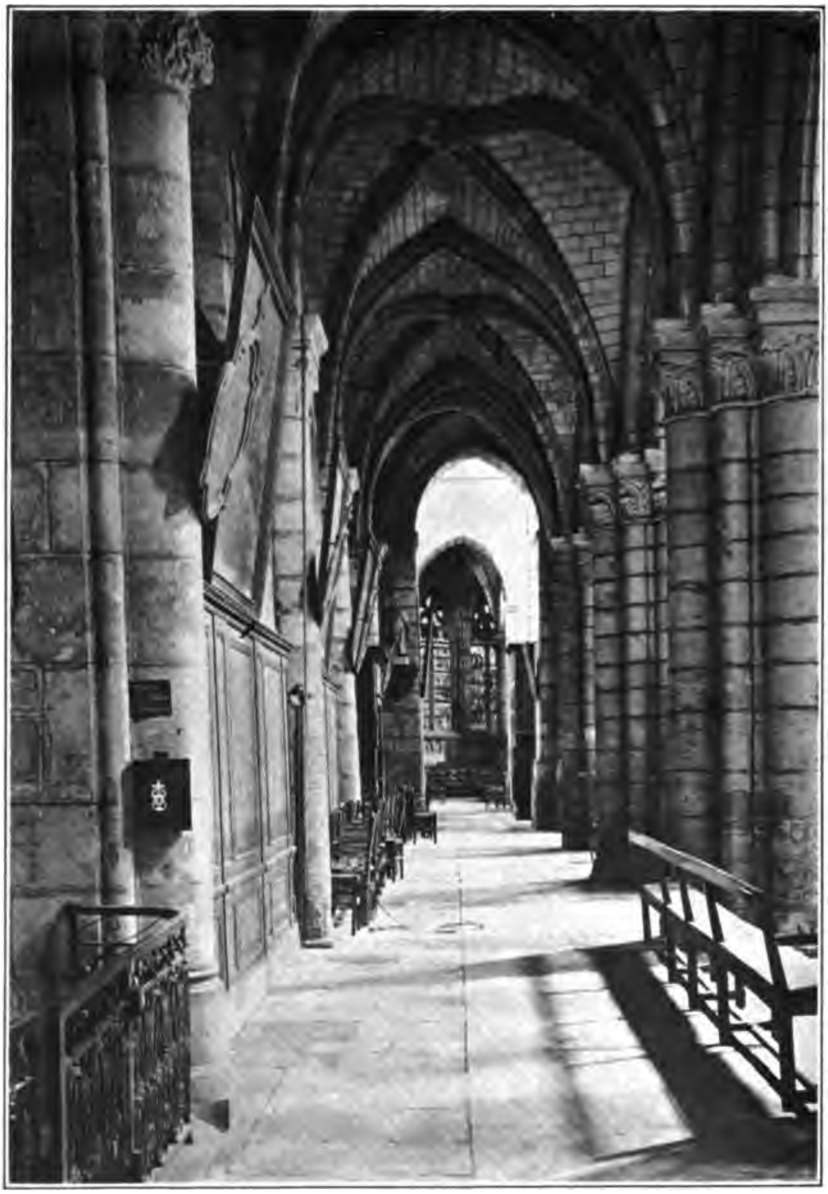
Sympathetic, or parallel, leans in windows are also found at Amiens (No. 62) and in Notre Dame (Nos. 99, 100). They also occur at St. Quentin (photo. not yet enlarged, No. 298, Series of 1903). These sympathetic window leans are related to a system of sympathetic leans in the setting of triforium or gallery columns (St. Quentin, Nos. 37-40; Amiens, Nos. 54, 59, 60; Notre Dame, Nos. 71-74). They are also related to similar arrangements in the setting of transept piers (Amiens, Nos. 54-62) and in the setting of engaged pilasters (St. Mark's, Venice, see Memoir No. 2). The motive is obviously to avoid contrasts of adjacent leaning and perpendicular lines which would lead to the detection or displeasing prominence of the primary leans.

10 Left aisle, looking toward the façade. Plumb-line suspended from second pilaster on the right; surveyor's rod near the line. The leans vary from one to three inches with a line of nine feet.

11 First chapel of left aisle. The plumb-line from capital shows lean of three inches in nine feet. Surveyor's rod beside the plumb-line. The outer wall of the chapel seen on the left is perpendicular. The inference as to constructive facts is obvious.

The curate of St. Loup is familiar with the constructive facts illustrated. He mentioned that the architect in charge of the church (a M. Aubertin) knew of the facts as constructive, and that he explained them as related to the principle of the horse-shoe arch. The curate is disposed to have the window of the right aisle rebuilt, because the lines of the mullions appeared to him to contrast disagreeably with the perpendiculars of the lamp-chains.

The curate called attention to a drop in the height of the vaulting, beginning at the bay adjacent to the choir, and mentioned the amount to be about three metres. This is a construction similar to the perspective illusion practiced in the Cathedral of Poitiers and described by Fergusson.



14. THE LEFT AISLE, ST. ALPIN, CHALONS.

ST. THOMAS, STRASSBURG. Nos. 12-13.

12 The nave, looking toward the façade. This is another church, like St. Loup at Chalons, in which the piers lean outward in straight lines, with divergence beginning at the pavement. The widening is pronounced in the piers nearest the spectator, at the choir, but is not visible at the first bay. Width of nave at the choir, thirty-two feet. The widening at the choir is about ten inches in a height of about forty feet.

For other churches which show greater widening at the choir or crossing, see Notre Dame, Paris; St. Pierre, Caen; St. Jean, Caen. The latter widens only at the crossing. Some churches which widen only at the apse have been mentioned under No. 5.

13 Left aisle looking toward choir end. Plumb-line suspended from the left pilaster. Widening two and a quarter inches in fifteen feet. The pilaster has an entasis. A valuable photograph for constructive demonstration, as regards questions of thrust.

ST. ALPIN. CHALONS. Nos. 14-16.

14 Left aisle. Plumb-line on second pier; surveyor's rod beside it. Widening four inches, with a line of fourteen feet. The widening is uniform for all pilasters in both aisles as far as the transepts.

15 Right aisle. Plumb-line on first pier. Widening two inches in fourteen feet. The view shows a depth in the chapel walls, of nine feet, which precludes thrust. Surveyor's rod at first pier.

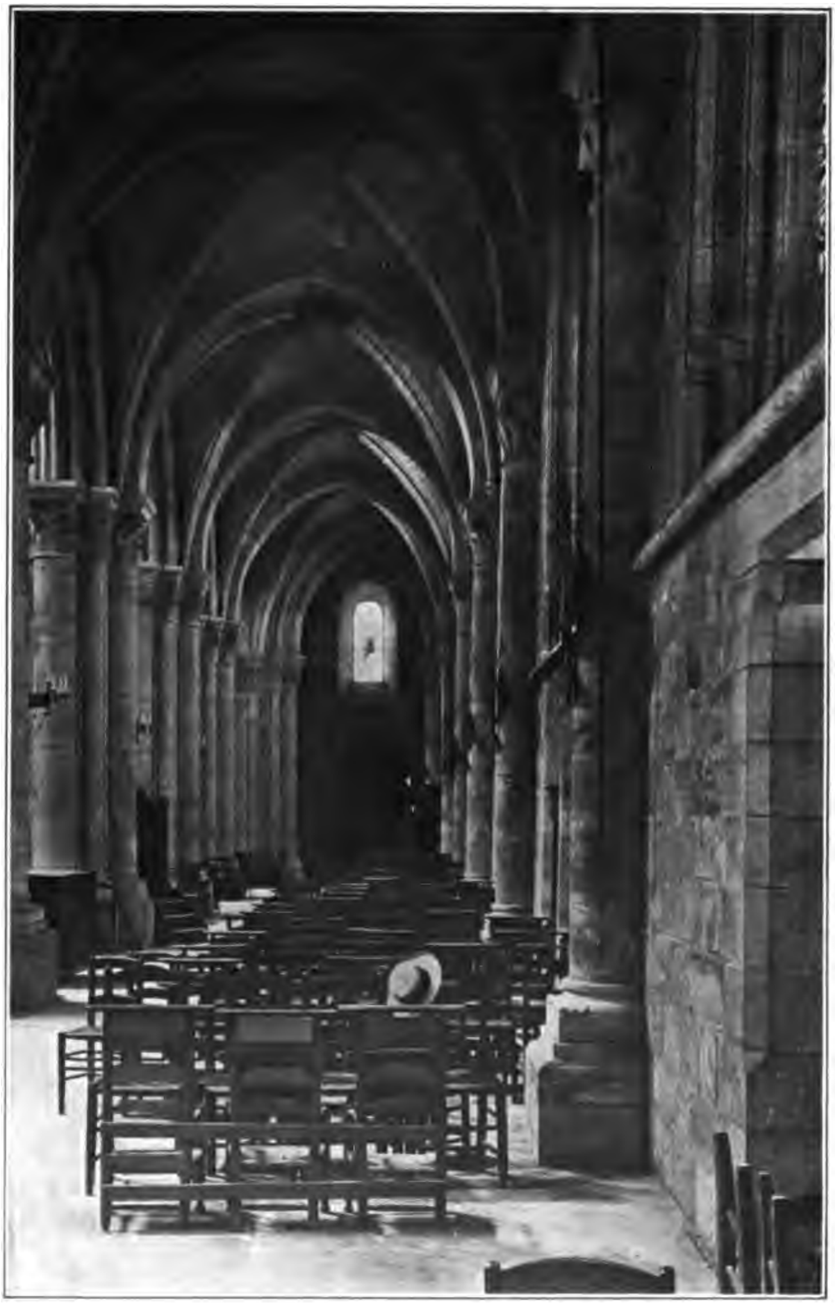
16 The nave; surveyor's rod at the entrance to the choir. The widening of the piers at the pulpit is seven inches in a height of twenty-seven feet. The nave is twenty-four feet wide. The widening at the choir is eleven inches in a height of eighteen feet.

St. Alpin is an important illustration of the evidence by which positive conclusions have been reached as to the constructive existence of the widening refinement. The widening of the nave is so delicate and the lack of constructive evidence in the matter of thrust is such that no conclusions could be drawn from the phenomena of the nave, when considered by themselves. But the evidence furnished by the pilasters of the side aisles is impregnable and establishes the probability that the widening of the nave is also constructive.

The pavement slopes up toward the choir one foot one inch in sixty-two feet. Compare Architectural Record Vol. VI., No. 2, for pavements sloping up toward the choir, (eighty-five observations in Italy). See also under Chartres, No. 125 of this Catalogue, for a list of French churches with sloping pavements.

NOTRE DAME. CHALONS. Nos 17-18.

17 Left aisle, looking toward the facade. The plumb-line shows three and a quarter inches lean in fifteen feet. There are well



17. THE LEFT AISLE OF NOTRE DAME AT CHALONS.
LOOKING TOWARD THE FAÇADE.

defined vertical curves in all pilasters. The identity of these curves with the classic entasis in this particular instance in unmistakable. The derivation from classic originals is equally positive in this instance. This photograph therefore raises the question whether the vertical curves of mediæval architecture may not have developed through independent mediæval observation and copies of the classic columns as well as by Byzantine transmission. The question may possibly be settled by more extended observations of the Romanesque in France. The close relations of this particular early Gothic church with the Romanesque are very apparent, and especially so in the style of the wall pilasters. The entasis appears in the Romanesque engaged columns of S. Michele at Lucca and in pilasters having classic reminiscent quality in Fiesole Cathedral (Arch. Rec., Vol. VII., No. 1.) It is frequent in mediæval columns of Italian Romanesque columnar basilicas.

18 The nave has no perceptible widening and does not exhibit vertical curves. The pilasters of the right aisle have the vertical curves but do not lean outward. Such variations in the application of the refinement are probably due to a change of direction during the construction. No other instance is known where outward constructive leans are confined to one aisle. S. Eustorgio at Milan is an instance of a nave without perceptible curves or widening, while the aisles have leaning pilasters of undoubtedly constructive character (Memoir No. 2).

ST. REMI, RHEIMS. Nos. 19-21.

19 Right aisle. Plumb-lines on first and second pilasters show leans of two and a quarter inches in nine feet.

20 Nave, sighting on the right side. The piers are perpendicular up to the height of the capitals. They lean outward from the capitals up. Width of nave at the pavement forty-four feet. Widening fourteen and a half inches in a height of fifty feet.

21 The transepts. The vertical bend is well shown in the foreground on the right and in the distance, on the left.

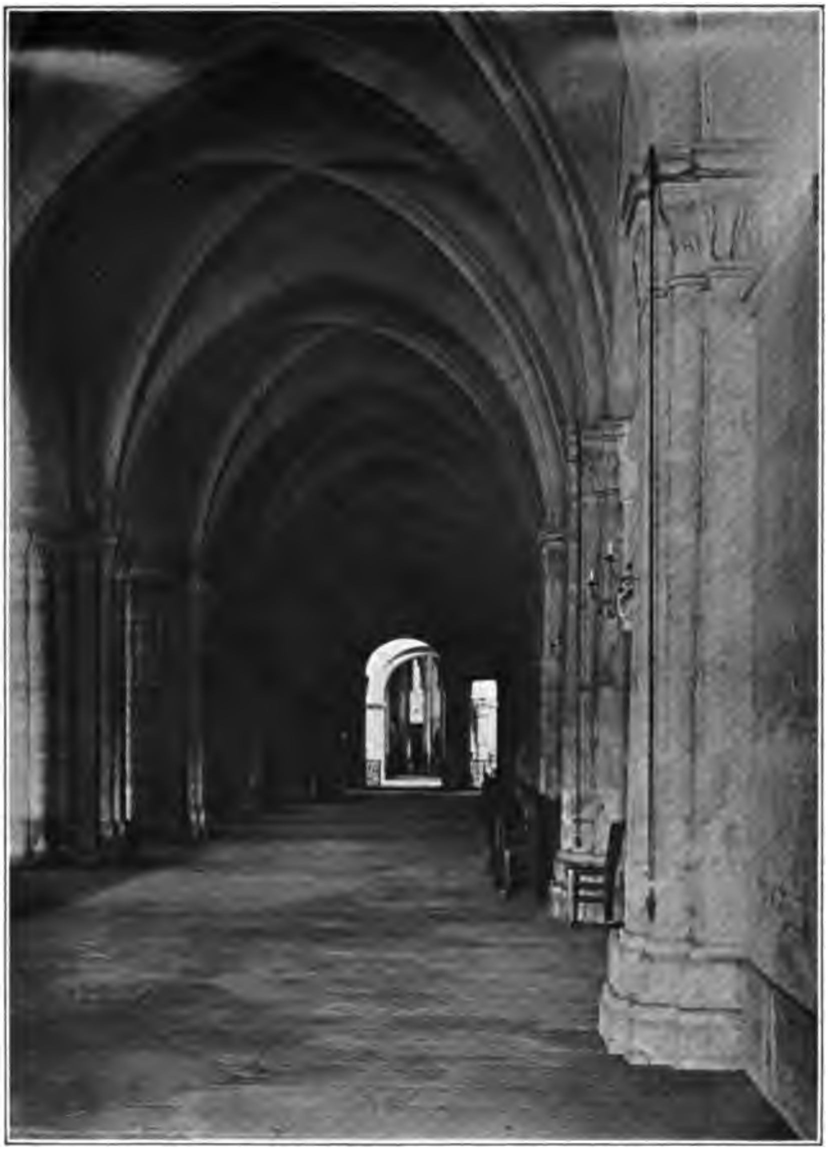
CATHEDRAL OF LAON. Nos. 22-28.

22 Views of the nave. At the fifth pier from entrance (eighth from
23 transept) the widening is nine inches in a height of fifty-two feet. Width of nave at pavement is thirty-six feet.

24 Views of the choir. At the springing of the arch which surrounds
25 the rose window of the choir the widening is ten inches.

26 Details of the choir windows, with plumb-lines, which are also
27 visible in the preceding views. The centre window widens five
28 inches in a height of thirty-two feet.

The pilasters adjacent to the plumb-lines exhibit extremely deli-



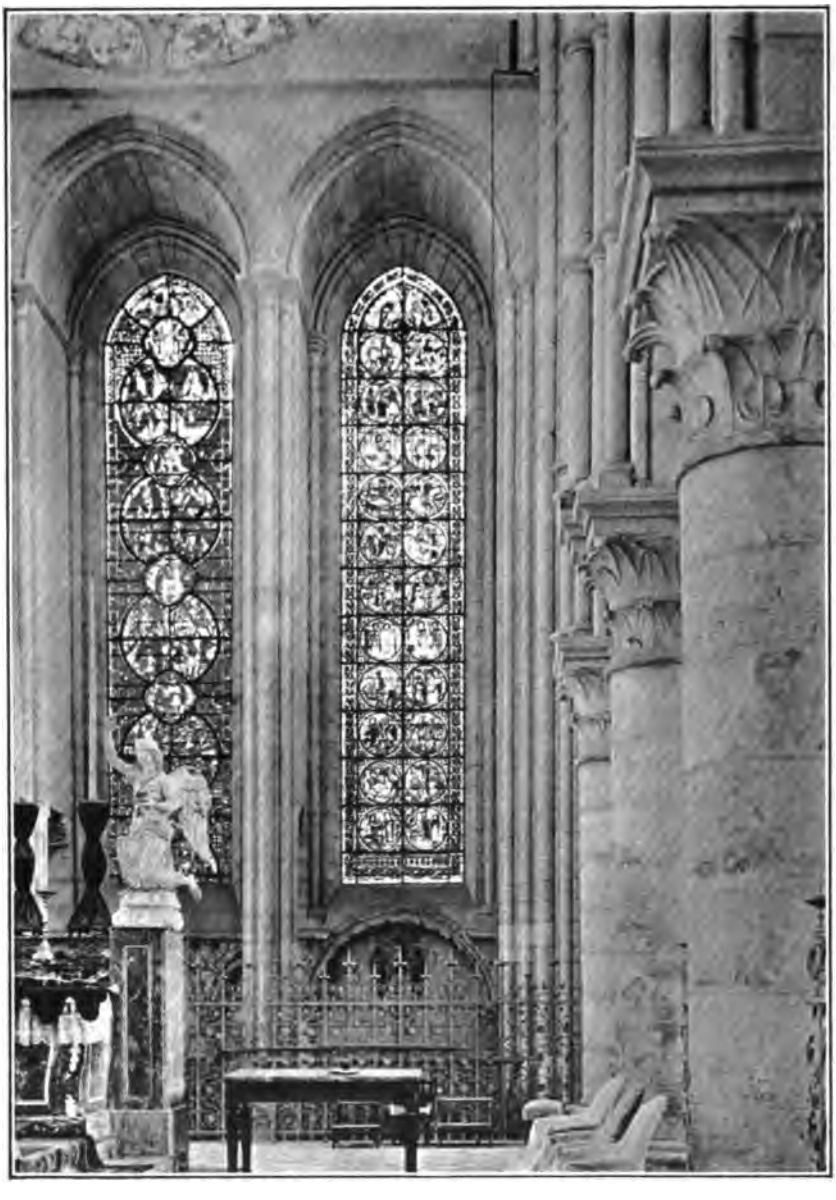
19. THE RIGHT AISLE, ST. REMI, RHEIMS.

cate vertical curves. The deflection is about five inches in a height of about thirty-nine feet.

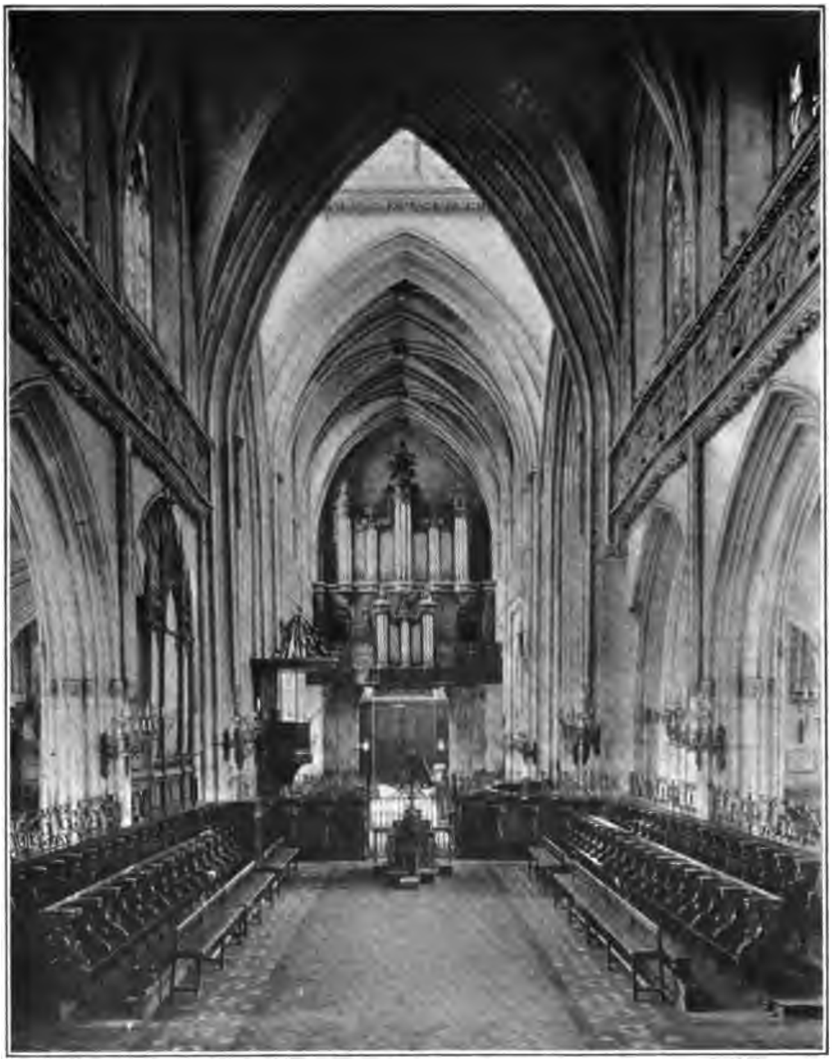
The conditions of construction in the east wall of the choir are such as to make the Cathedral of Laon one of the most interesting illustrations of intentional vertical curvature in France.

ST. JEAN, CAEN. No. 29.

29 The nave, from the High Altar, looking toward the façade. Well defined widening of 10 inches in the arches at the crossing. The



27. THE RIGHT SIDE OF THE CHOIR, CATHEDRAL OF LAON.



29. ST. JEAN, CAEN, FROM THE CHOIR.

inclination of the second pier on the right, at the transept, from the pavement to the springing of the arch, was found to be five inches by plumb measurement (height thirty-five and a half feet).

The perpendicular is established by a plumb-line suspended from a pole, which projects from the pulpit.

The improvement of effect obtained by the widening is well illustrated by this view. The church is late Gothic, apparently 16th century.

ST. PIERRE, CAEN. Nos 30-32.

30 Vertical bends, with divergence beginning at the capitals. Width of the nave, at the pavement, twenty-four feet six inches. Widening

twenty inches in a height of fifty feet. The perpendicular is established by a plumb-line hung from the pulpit. This pronounced widening is developed in the choir. Near the main entrance it is much less perceptible.

St. Jean and St. Pierre at Caen are the only late Gothic churches in which the widening or vertical bends have so far been found (The choir of St. Pierre is Sixteenth Century). On the other hand it must be borne in mind that the late Gothic is not largely represented in the localities which were visited. The following are among the late Gothic churches which have been noted as lacking this refinement: St. Maclou at Rouen, the pilgrimage church of L'Épine near Chalons, the Cathedral of St. Lo, the church of St. Nicholas at Coutances, and St. Stephen's at Vienna.

These observations bear on the point that although the Renaissance reaction against the Gothic must be considered as the main cause of the disappearance of the mediæval refinements, there was undoubtedly a falling off in this respect in the Gothic decadence. See also No. 130 for the rarity of Renaissance examples of the widening. For the gradual disappearance of the widening system it is also extremely significant that all known instances of marked widening in the exterior walls or pilasters of the side aisles belong to the Romanesque or very early Gothic. It is natural that the system should have been abandoned for the side aisles before it was abandoned for the nave. It is therefore in point to note the early dates of St. Thomas at Strassburg, of St. Loup, St. Alpin, and Notre Dame at Chalons, and of St. Remi at Rheims, in which the pronounced leans have been illustrated for the exterior pilasters of the side aisles. Another Romanesque example for leans in the exterior pilasters of the side aisles is the church of the monastery of Montierneuf at Poitiers, Nos. 127-129. The same rule holds for Italy. Compare Memoir No. 2 for S. Michele at Pavia, S. Ambrogio at Milan, S. Eustorgio at Milan, (Romanesque); and for S. Lorenzo at Vicenza and S. Agostino at Orvieto (early Gothic). These are the notable Italian examples of widening in the exterior walls or pilasters of the aisles.

31 Ceiling of the nave showing curve in plan. For surveys of similar deflections in Italy see Arch. Rec., Vol. VI., No. 4.

The converging lines in this photograph suggest the remark that it may have been one purpose of the widening refinement to correct the convergence of vertical lines, which is due to perspective. There are obvious reasons why such a converging effect in the piers of church interiors might be considered objectionable.

32 Curve in plan of the left aisle, as shown by the central line of the vaulting. This view raises the point that the explanation frequently offered for deflections in plan of the choir, viz: that they

represent the bending of the head of the Saviour on the Cross, cannot apply to curves in plan of the entire church. See Arch. Rec., Vol. VI, No. 3, page 405.

This view shows perpendicular lines in the outer pilasters of the aisle. The aisles with exterior outward leans, illustrated in earlier numbers, are exceptional cases and have been grouped together on account of the constructive intention which they so clearly exhibit.

ST. OUEN, ROUEN. No. 33.

33 The curve in plan is apparent in the ceiling. There is a return curve toward the façade and a small portion of this return curve is included in this view. Compare Arch. Rec., Vol. VI., No. 4, for Italian counterparts, especially the Cathedral of Fiesole. No vertical bends or curves were observed in this church.

This view offers another illustration of the disagreeable effect of piers converging in perspective. (See No. 31). Such a disagreeable effect may be due to the fact that we are unaccustomed to pictures taken with the camera pointed upward, but it is still probable that one motive of the widening was to counteract such perspective convergence.

CHURCH OF ST. QUENTIN. Nos. 34-42.

34 Central view of the nave. The piers curve vertically. Widening at the crossing, ~~four and a half~~ feet in a height of eighty feet. Width of the nave about thirty-four feet.

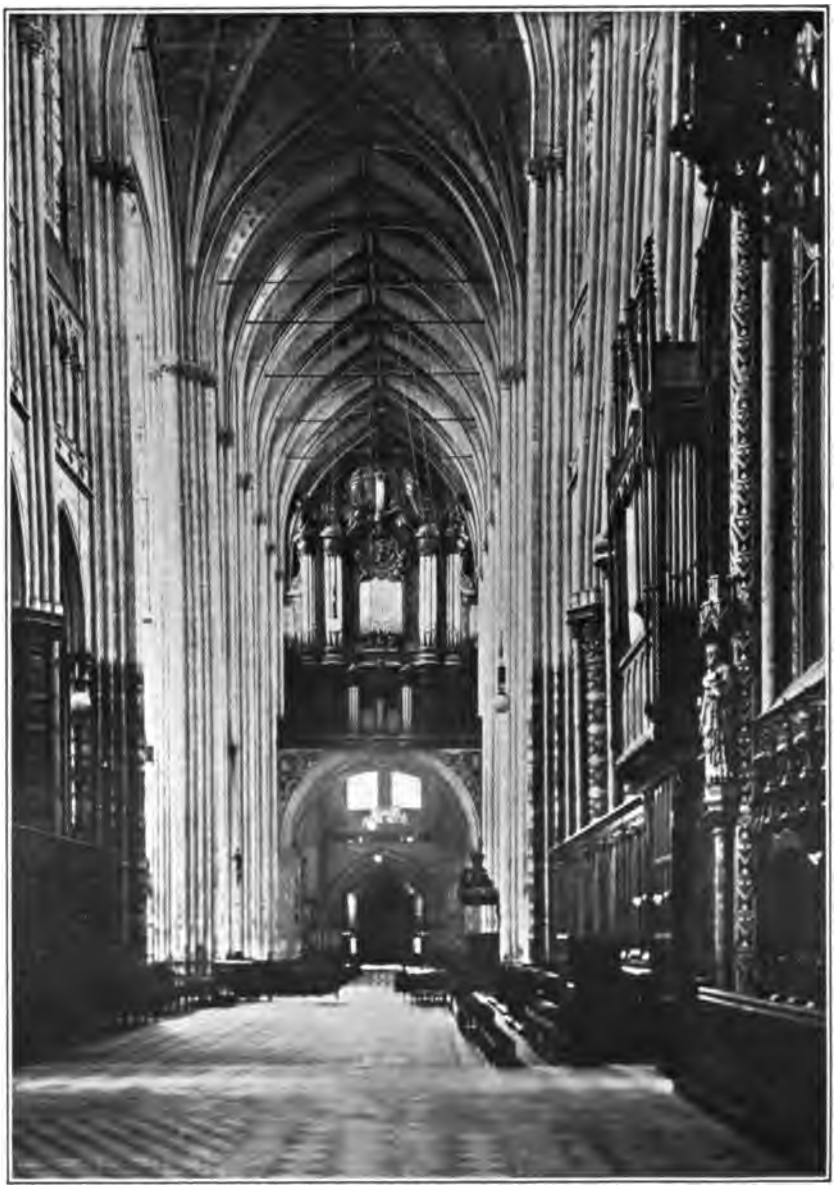
This church has the most pronounced ~~widening~~ of any so far observed. The general avoidance of such an excessive divergence shows the general wish that it should be inconspicuous. It must be remembered, however, that the divergence here is much less conspicuous in the church than in the photographs. The effect is discounted in the church by the convergence of perspective.

The Sacristan said that the architect, M. Benard, who had been in charge of the repairs of the church for thirty-six years previous to his death, a few years ago, attributed its peculiar construction to the "hardiesse" of the mediæval builders.

35 Right side of the nave. Note the remarkable bend on the left side of the choir. Note that the clerestory window in the left transept has its mullion built parallel to the lean of the nave piers. Note that the triforium column below this mullion is set parallel to this lean. Compare No. 37 for the triforium.

36 The nave, looking from the choir toward the façade. An excellent view of the vertical curves, also showing the remarkable bend on the right side of the choir (left side in No. 35).

This view shows the widening to be less pronounced near the main entrance, a fact also apparent in Nos. 34, 35. This is also true



36. THE CHURCH OF ST. QUENTIN. FROM THE CHOIR.

in St. Thomas at Strassburg, in S. Maria della Pieve at Arezzo, in St. Pierre at Caen and is probably a frequent arrangement. In Notre Dame at Paris the leans of the crossing piers are much more pronounced than those of the nave or choir.

37 From the left aisle looking through transept to choir.

38 Return view of the left aisle taken from choir looking toward entrance.

39 From right aisle looking through transept to choir.

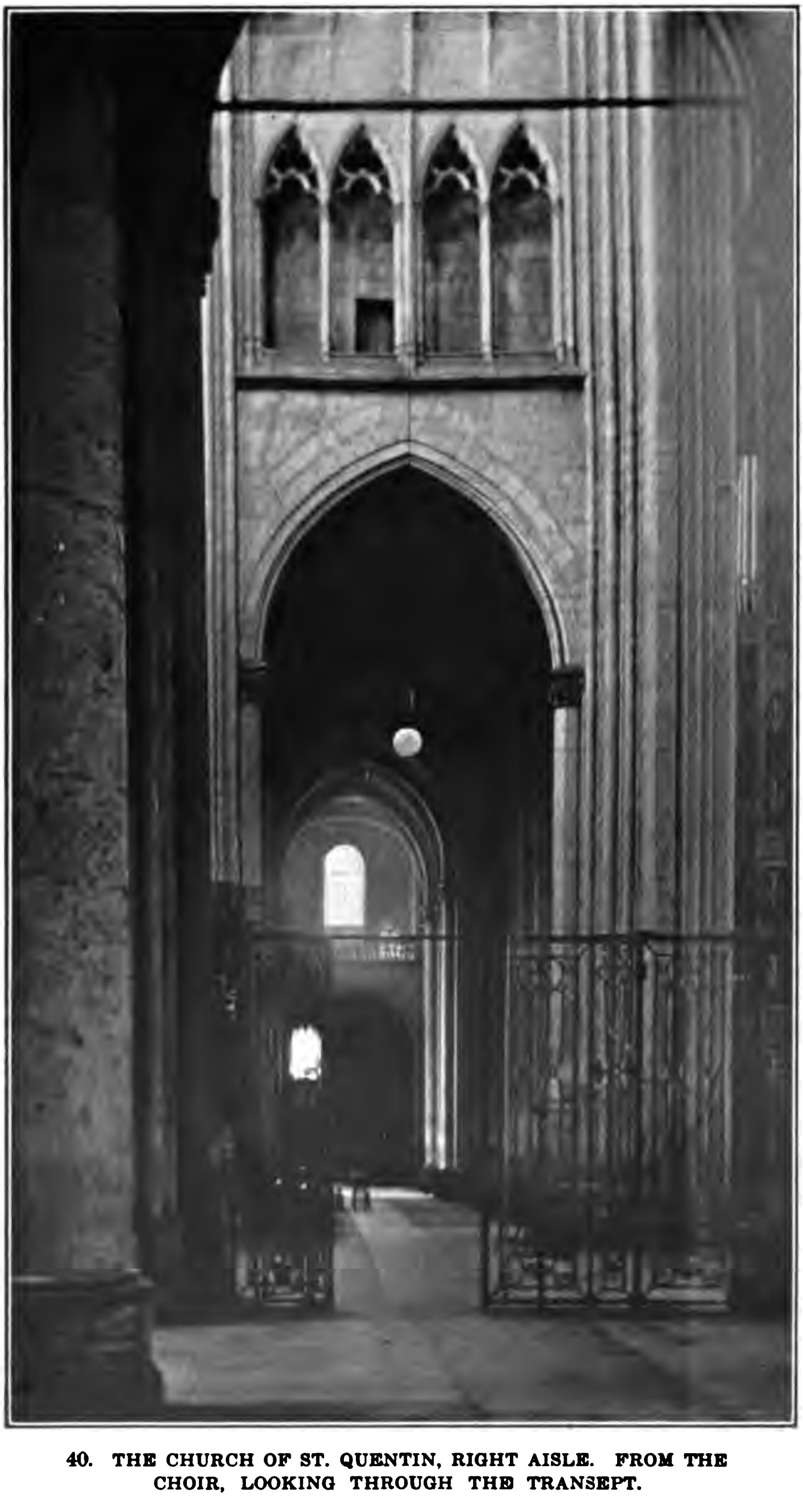
40 Return view of the right aisle taken from choir looking toward entrance.

These views show an interesting special feature at St. Quentin to be that the aisles widen on *both* sides, as far as the arches at the crossing are concerned. (In No. 37, the widening is eight inches in a height of thirty feet.) In all churches so far illustrated the aisle widening has been effected by a lean in only one direction, i. e., on the outer side (this also holds of the Italian churches described in Memoir No. 2). Here there is a slight lean also on the side of the nave, so that the crossing piers lean slightly into the nave before they curve away from it. (Most clearly seen in No. 40, least apparent in No. 38). Every one of these photographs shows above the aisle arch a slight return curve of the exterior pier in the direction toward the perpendicular, but every photograph also shows that the lean continues, though in diminished degree, toward the outer wall of the church (to be tested by relation to the lamp-chains). Perpendiculars are established in each picture by plumb-lines which are hung over the railings. They are also established by the lamp-chains.

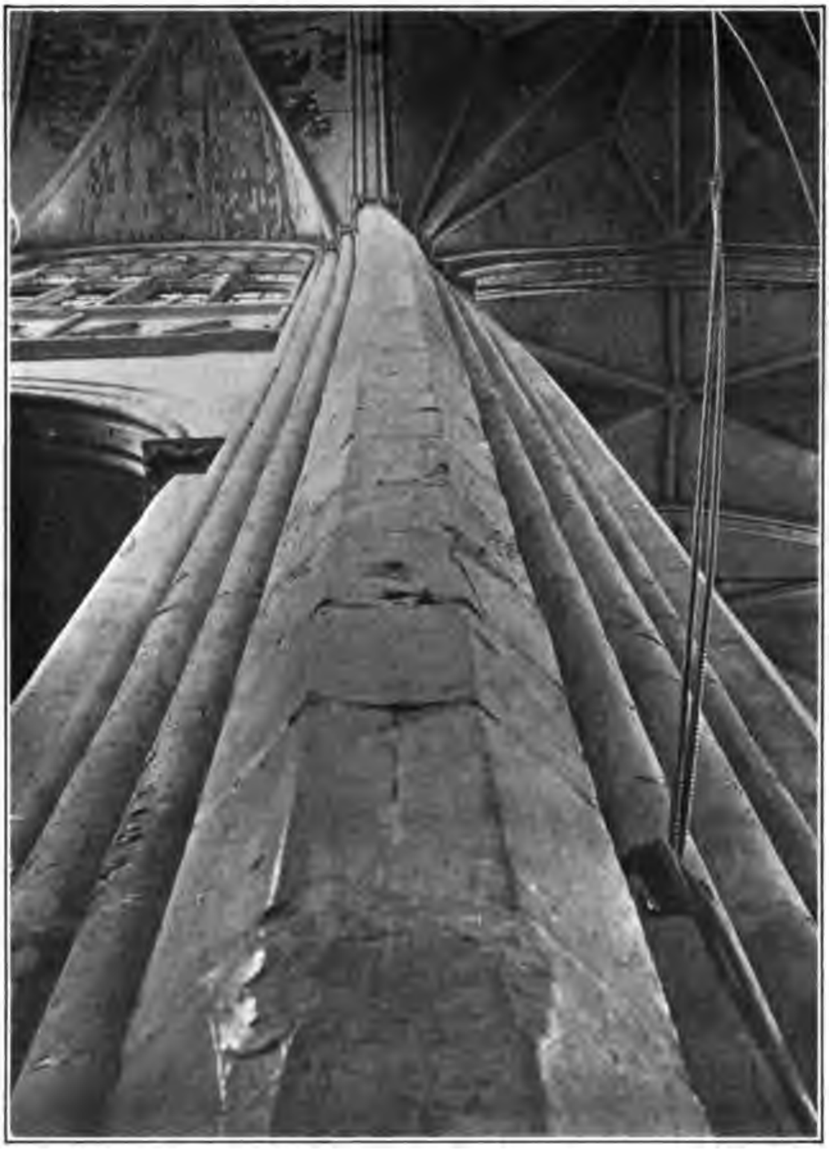
Comparison with the lamp-chains will show that the triforium columns are set to lean parallel with the leans of the crossing piers. This is also the case at Amiens and in Notre Dame at Paris. See explanation of sympathetic leans under No. 9.

41 Vertical curves of the east side of the south-west crossing pier. View looking up the pier seen in No. 40, on the side visible in that view. Considered from the point of view of the entrance this is the first pier at the crossing on the right. This pier is also seen on the left in No. 36.

42 Vertical curves of the south side of the same pier. View looking up the pier. This face is at right angles to the face shown by No. 41 and exhibits the curves of the transept which intersect those of the nave. The two systems of curves and of widening cross one another at right angles. Each pier at the crossing has therefore two separate and distinct vertical curves, one bending south or north and the other bending east or west. (The most remarkable development in detail of intersecting systems for nave and transept is that of St. Mark's at Venice.)



40. THE CHURCH OF ST. QUENTIN, RIGHT AISLE. FROM THE CHOIR, LOOKING THROUGH THE TRANSEPT.

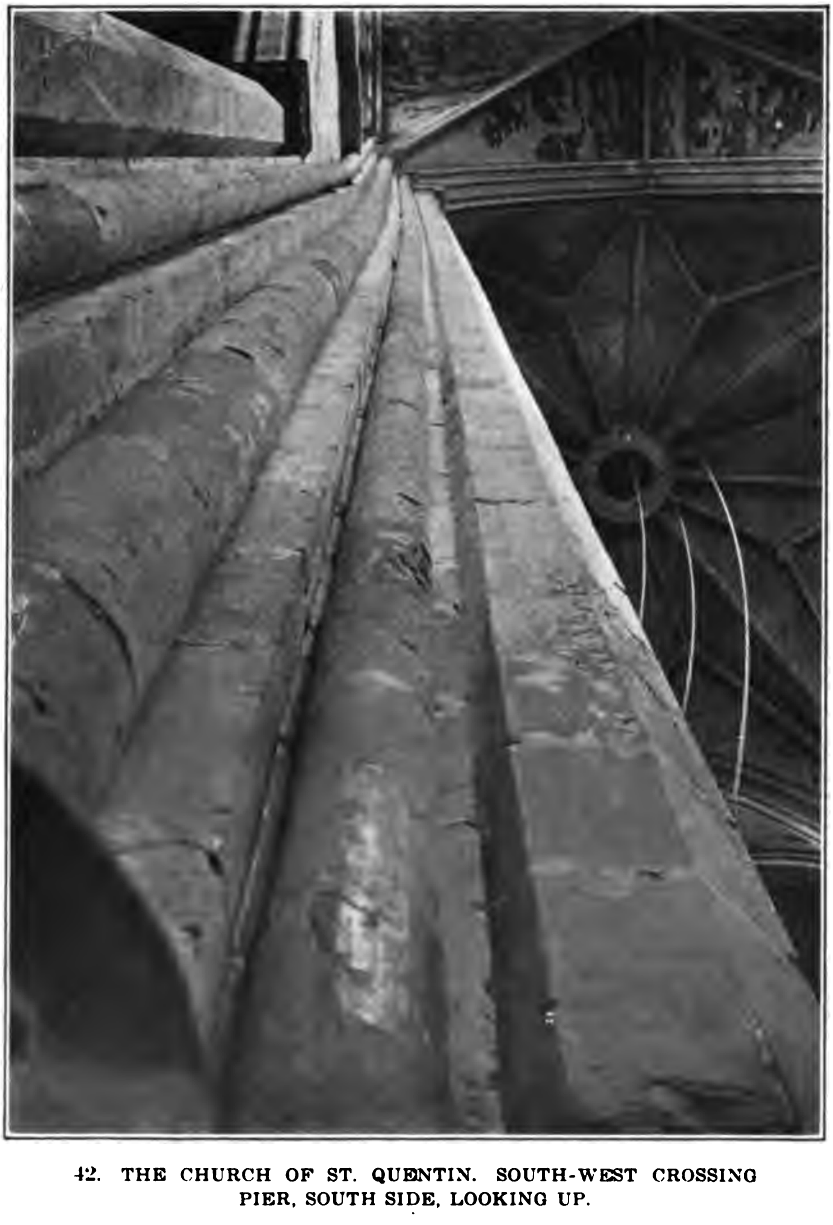


41. THE CHURCH OF ST. QUENTIN. SOUTH-WEST CROSSING PIER, EAST SIDE, LOOKING UP.

Cathedral of Amiens.

Nos. 43-62.

43 Vertical curves of the nave, sighting on the right side. By plumb, taken through an opening in the vaulting, the first pier on the right at the crossing curves forward into the nave 0.20 and curves outward, away from the nave 1.20, making a total bend



42. THE CHURCH OF ST. QUENTIN. SOUTH-WEST CROSSING PIER, SOUTH SIDE, LOOKING UP.

of 1.40.* According to these estimates the total widening at the first pair of piers at the crossing is 2.80; assuming an identical curvature in the corresponding opposite pier and it certainly approximates to this very closely.

The existence of a constructive widening in the nave is well

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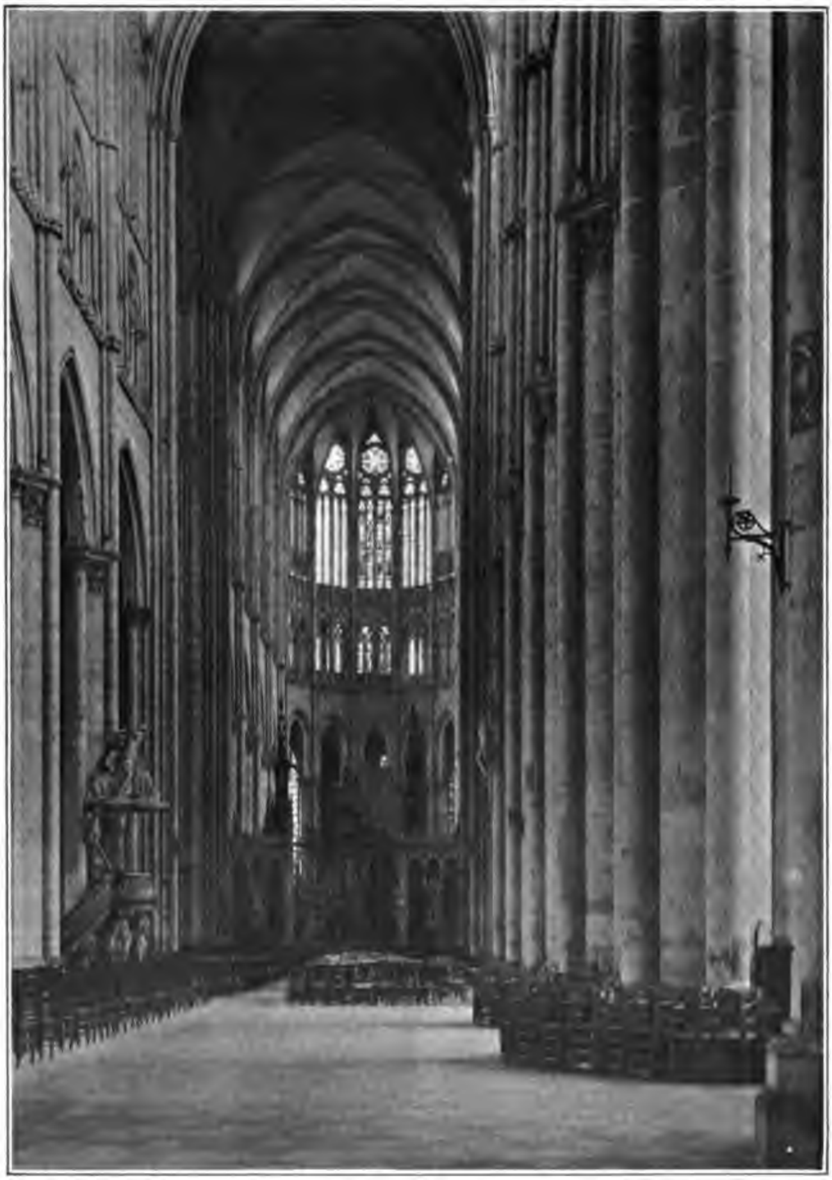
*In order to preserve the exact record for Amiens, the measurements are quoted in decimals of a foot.



43. CATHEDRAL OF AMIENS. RIGHT SIDE OF THE NAVE.

known to the church authorities. It was reported to me by the *Suisse* as amounting to one metre, which is very close to the results just mentioned. Bædeker notes this peculiarity of the nave at Amiens, but describes it incorrectly. The piers are described as "tapering toward the top, so that the vaulting seems actually wider than the pavement below." The piers do not taper in the nave. They bend outwards, preserving the same dimensions. The vaulting not only seems wider, but it actually is wider.

44 Vertical curves of the transepts. From the triforium of the right transept. This view is an important illustration of vertical curves without widening: i. e., when distances between the bases of the piers are compared with those between piers at the height of the capitals. It is a general rule that the vertical curves in transepts do not widen or that they widen much less than in the naves. St. Quentin offers an illustration of this general rule.

45 Vertical curve in a pier of the right transept, photographed sighting up the pier. A plumb-line is suspended from a stick which projects from the triforium. The stick breaks the view of the curve in the clerestory.

46 Vertical curves of the nave, photographed from the organ gallery. Wide-angle view.

47 Vertical curves of the nave, photographed from the organ gallery. A plumb-line is suspended from a stick which projects from the triforium, beside the first pier at the crossing on the right.

48 Vertical curves of the nave, from the triforium of the choir.

49-52 Interiors of the triforium gallery, with plumb-lines, showing the outward leans of the piers as seen from the rear. These leans are uniform in all parts of the triforium.

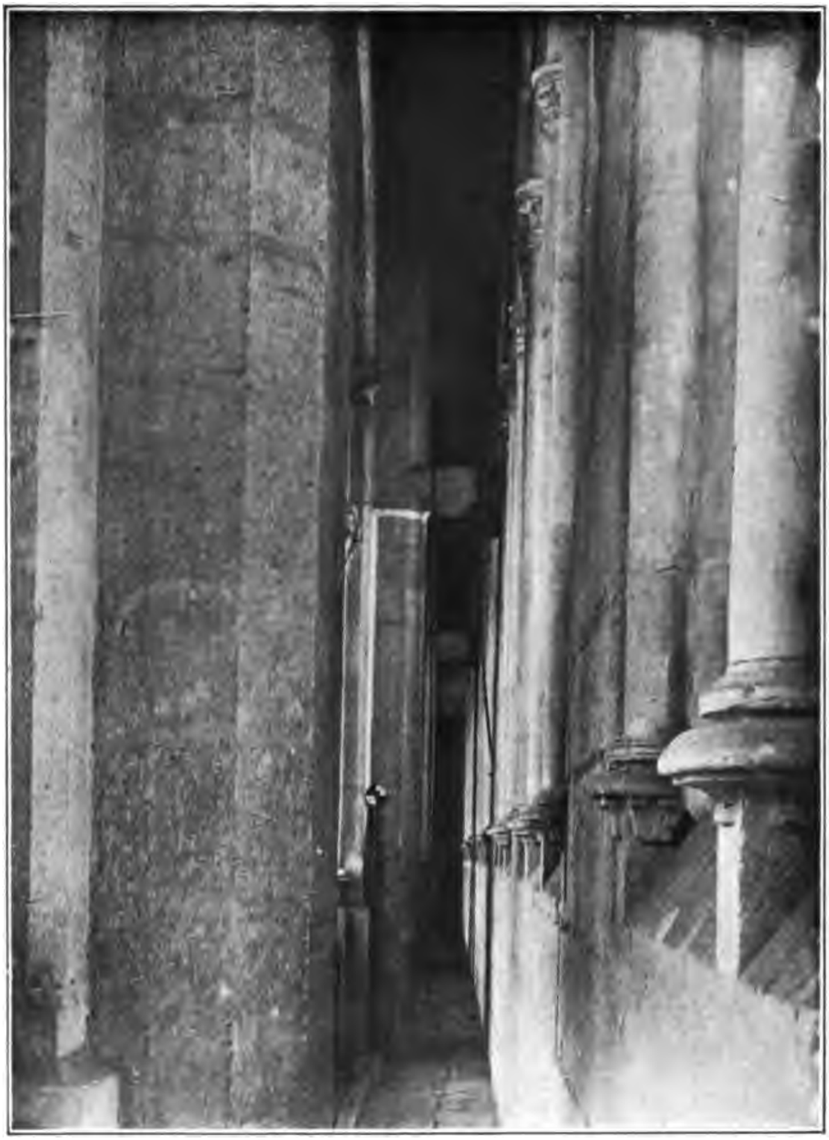
49 Interior of the south side, choir triforium, looking toward the transept. The wall is on the left, the piers are on the right. The piers lean to the left.

50 Nearer view of the same.

51 Interior of the north side, choir triforium, looking toward the transept. The wall is on the right, the piers are on the left. The piers lean to the right.

52 Interior of the north side, triforium of the nave, looking toward the façade. The piers lean to the right.

53 Right aisle, looking across the transept toward the façade. The first pier on the left beyond the altar (see No. 55) belongs to the transept system. Beyond it lies the transept aisle, where the pilasters face chapel walls about thirty-two feet deep. (These walls rise above the roof of the aisle as buttresses.) The pilasters of these buttress walls exhibit very delicate vertical curves under conditions precluding thrust. For the derivation of such curves from Romanesque pilasters, see No. 17.



51. CATHEDRAL, AMIENS. CHOIR TRIFORIUM, NORTH SIDE.

We next note the plumb-line hanging (from the triforium gallery) beside the pier of the transept system (left side of the picture). The inclination is about four inches in a height of about forty feet. This picture should now be compared with the corresponding photograph for left aisle (No. 59), in which two plumb-lines are suspended from the triforium. We thus become aware of a widening system in the piers of the arches which open into the aisles from the transepts.

The following photographs, Nos. 54-62 inclusive, are devoted to the illustration of this system as found in all the piers of both transepts. The facts illustrated were first made known to the church authorities at Amiens by the suspension of the survey plumb-lines. They exhibited the greatest interest in them and were most helpful in giving full facilities for the prosecution of the investigation.

54 View looking across the right transept to the right aisle of the choir (reversing the position taken in No. 53). Two plumb-lines are suspended from the triforium. The surveyor's rod (six feet) is set against the second pier on the left. Note the bend in this pier, which curves slightly into the nave and then curves away from it. This lean to the left is 0.42 in forty feet, the lean to the right is 0.30. Nos. 60 and 59 show similar bends in the left aisle.

We thus become aware of a widening system at the openings from the transepts into the aisles of nave and choir which corresponds to that at St. Quentin, a system in which both sides of the aisle are widened, so that one side leans into the nave. A comparison of Nos. 54, 59, 60 with Nos. 37, 38, 39, 40 for St. Quentin is suggested, as the same arrangements are more clearly seen in the St. Quentin pictures.

The triforium columns and window mullions are set leaning to the right, parallel with the lean of the crossing pier; compare Nos. 59 and 60. Compare St. Quentin, Nos. 37, 38, 39, 40, and Notre Dame, Nos. 71-74. Special photographs of these triforium columns at Amiens with plumb-lines, are included in the survey photographs but have not been enlarged.

55 View from a position nearly corresponding to that of No. 54, but taken with the camera set farther to the left, so that a portion of the second aisle of the choir is now visible. Two plumb-lines, as before. Surveyor's rod, as before. The bend illustrated by No. 54 is again visible. The leans of the piers on the right are better seen in this view, which also serves to explain the relation of the next picture to No. 54 as regards location.

56 Second right choir aisle, looking through the transept. Two plumb-lines; surveyor's rod near right plumb-line. This view shows the extension of the system of leans to the outer piers of the second aisle. The right pier leans off 0.33. (The disk of the surveyor's rod is five and a half inches in diameter.) The mate to this view in the left transept is No. 61. The same facts appear there.

57 The same aisle (second choir aisle) photographed in reverse direction, looking west through the transept to the transept wall. Plumb-line from the triforium gallery beside the transept pier on the left. All piers in this view are parallel. Consequently all the

piers exhibit the lean which is verified by the plumb-line for one of them.

58 Detail of No. 57. Leaning piers of the right transept, looking west. Plumb-line and surveyor's rod on the left. All piers lean to the left, including those which are attached to the transept wall. The opposite piers of the same transept are shown by 56. The counterpart of this view in the left transept is No. 62 in which the window mullion is seen to have been made parallel with the leaning pier.

59 Left aisle, looking through the transept toward the façade. Two plumb-lines from triforium gallery. This view is the counterpart of No. 53 for the right aisle. The same facts are illustrated: viz., the vertical curves of the pilasters on the outer side of the aisle; and the widening of the piers of the arches which open from the transept into the aisle. (The minimum deflection in the leans of the transept piers is 0.23 in forty feet, the maximum deflection is 0.42. About 0.30 is the general rule.) The return bend of the ribs of the crossing pier is also included in this view, and is apparent by comparison with the left plumb-line. For this return bend compare Nos 54, 55.

The triforium columns are set leaning to the right, parallel with the outward lean of the crossing pier.

60 Left aisle of the choir, taken through the transept. Two plumb-lines from triforium gallery; surveyor's rod near the right plumb-line. This view is the counterpart of No. 54 for the right aisle. The choir aisle widens left and right; 0.30 left, 0.42 right.

This view also shows the return curve of the crossing pier above the aisle widening, as it bends back to produce the widening of the nave. The same system appears in Nos. 54, 55 and 59 and also holds at St. Quentin, as elsewhere explained. (Nos. 37, 38, 39, 40.)

The right pilaster of the aisle arch is seen to taper in this view. In other words the widening on the right side is partly effected by the slight outward lean of the pier and partly effected by the tapering of the pilaster of the arch. The note-book record mentions the same arrangement in No. 38 at St. Quentin. In No. 59 at Amiens the left pilaster of the aisle arch is seen to be actually built with a slight stepping back of the masonry, about six feet below the capital. The pilaster of the aisle arch appears to taper on the left side in No. 54. More accurate observations would probably show that this tapering is found in all the crossing piers at Amiens and St. Quentin on the side next the nave.

The triforium columns and window mullions are set leaning to the left, parallel with the outward lean of the crossing pier. Compare notes on this point under No. 54.

61 View looking through the transept to the second left choir aisle

(adjacent to No. 60). This view is the counterpart of No. 56, and shows that identical arrangements are found on both sides of the church. Two plumb-lines from triforium gallery; surveyor's rod near left plumb-line. This plumb-line shows a lean of 0.23.

62 View from second left choir aisle looking through the transept to the transept wall. This view is the reverse of No. 61 and the counterpart of No. 57. Two plumb-lines from triforium gallery; surveyor's rod near right plumb-line. Right pier leans 0.40 in forty feet. The pier beyond this, which is attached to the transept wall, has a parallel lean.

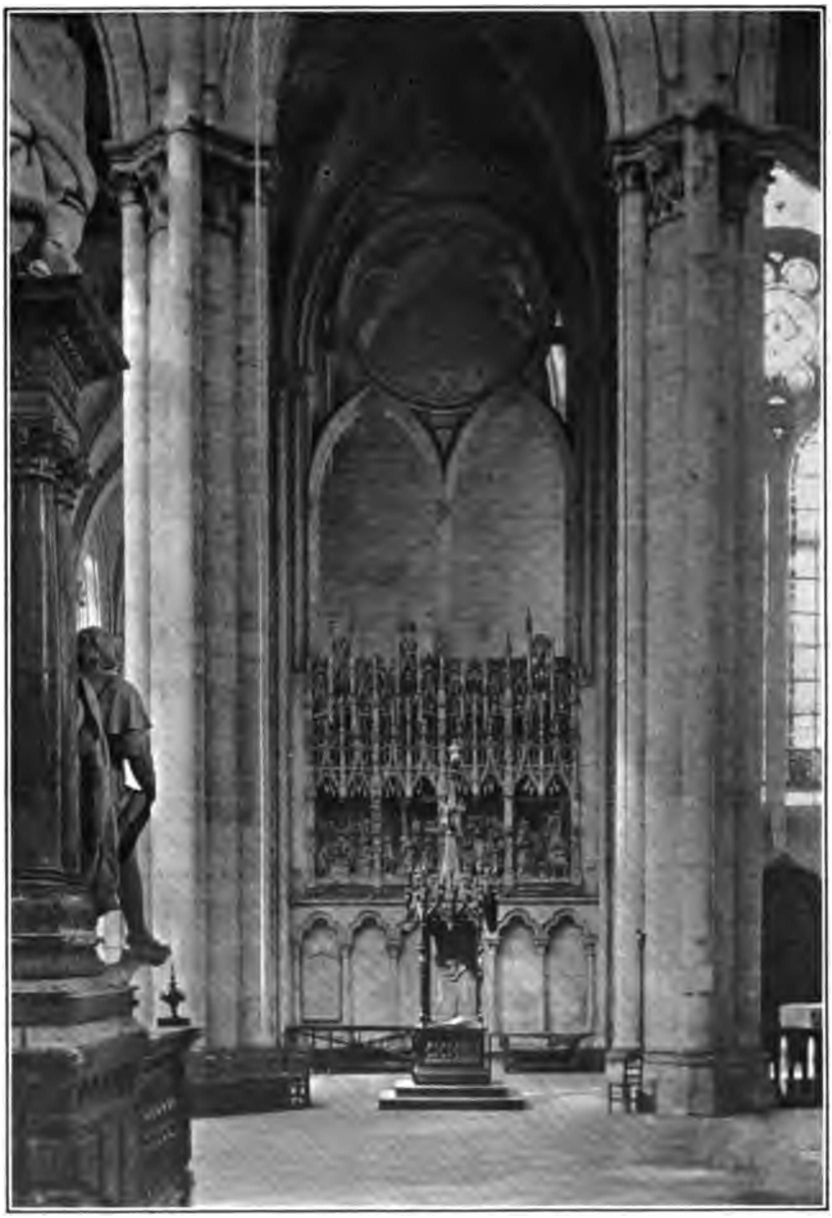
The mullion of the window on the right is also built parallel to the lean. For sympathetic window leans at Chalons see No. 9. For window leans in Notre Dame at Paris see Nos. 99-100.

The remarkable fact regarding the window mullion at Amiens was first noticed in the photographic print during the return voyage to the United States and consequently no observation was made for the corresponding window of the right transept. In Notre Dame at Paris similar facts were observed for corresponding windows on opposite sides of the church. The explanation for such arrangements must be, as given under No. 9, the desire to avoid detection or an over-conspicuous prominence, of the primary leans, which would have resulted from the contrast between leans and perpendiculars. As regards the leans of the transept piers those of the first aisle on either side would be called for by the widening system. Those beyond them on either side would be called for at one and the same time by the continuation of the widening system and by the wish not to antagonize and counteract the effects already obtained. At all events the plumbs in St. Mark's at Venice and in Notre Dame at Paris have revealed a corresponding system of transept leans in those churches (Memoir No. 2). At present writing the Church of St. Quentin, Amiens Cathedral, St. Marks at Venice, and Notre Dame, are the only churches known to possess this peculiar system of transept leans—which continues the system parallel to that of the nave, besides employing an independent system at right angles to that of the nave. On the other hand in the matter of intersecting systems the most interesting analogies are those between St. Mark's and the Church of St. Quentin.

The intersecting system at Amiens is shown by comparing Nos. 43 and 44.

A sympathetic window lean is also shown for St. Quentin by a survey photograph which has not been enlarged. It is found on the west side of the north transept; No. 298 of the original 5″ x 7″ prints.

Plumbs in the angles of the transept galleries show that the transept end walls repeat the leans of the transept piers. This is also the case at St. Quentin and in Notre Dame at Paris.



62. CATHEDRAL OF AMIENS. FROM THE SECOND LEFT AISLE OF THE CHOIR, LOOKING WEST. VIEW OF THE LEANING MULLION.

Notre Dame, Paris.

Nos. 63-111.

The Vertical Curves and the Widening.

63 The nave from the entrance. Showing vertical curves in the nave and widening at the transept.

This view shows the widening to be much more pronounced in the piers at the crossing than in the piers of nave and choir. On the other hand the curves are much more pronounced in the nave and choir than they are in the piers at the crossing. As distinct from the crossing piers which begin to diverge near the pavement, the piers of the nave and choir, with their continuing vaulting shafts, lean into the nave slightly, up to the capitals of the triforium, but with return curve beginning at the gallery parapets. The widening in the upper part of the nave is about seven and a half inches. That the bends into the nave are not due to thrust appears from the fact that the gallery piers do not lean out on the inner side. See plumb-line in No. 75. By actual plumb the first pier on the right in No. 63 leans into the nave 0.23, up to the height of the capital.

The vertical bulge into the nave is much more pronounced on the right side of the nave than on the left. This is probably due to the curve in plan of the gallery, which is convex to the nave on the right side. See No. 75.

The perpendicular is established by a plumb-line suspended from a pole which projects from the gallery beside the first pier on the right, at the crossing.

64 View of the second pier on the left beyond the railing, as seen in No. 63. The vertical curve, sighting upward. Plumb-line suspended from the gallery.

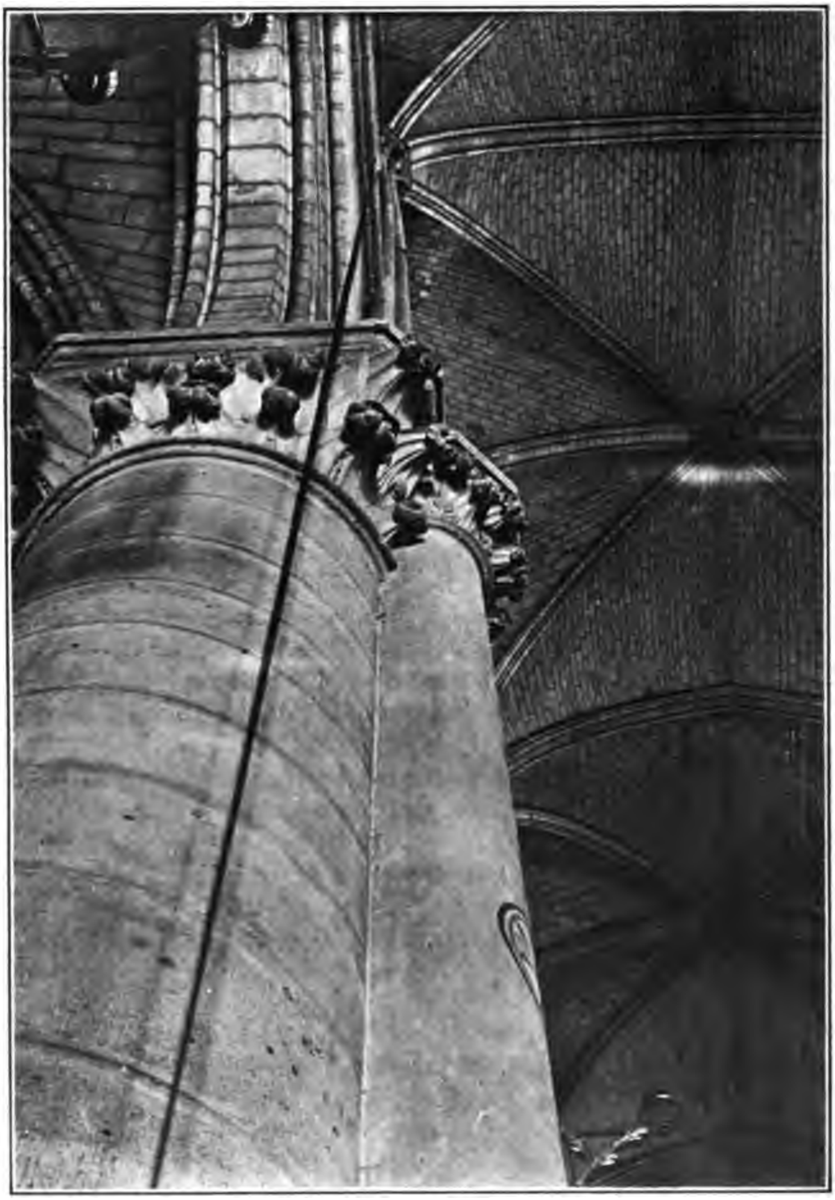
65 The nave, photographed to show the widening at the transept. Plumb-line from the gallery on the right. The total widening in the first pair of piers at the transept is about two feet four inches. Width of nave forty-two feet, height of the vaulting one hundred and ten feet.

66 Another view, corresponding to 65, but including the capitals of the first pair of piers at the crossing. Plumb-line from the gallery on the right.

67 Vertical curves of the nave, from the centre of the organ gallery. Plumb-line from the right gallery beside the first pier at the crossing. The widening in the clerestory connected with the curves in the nave is about seven and a half inches.

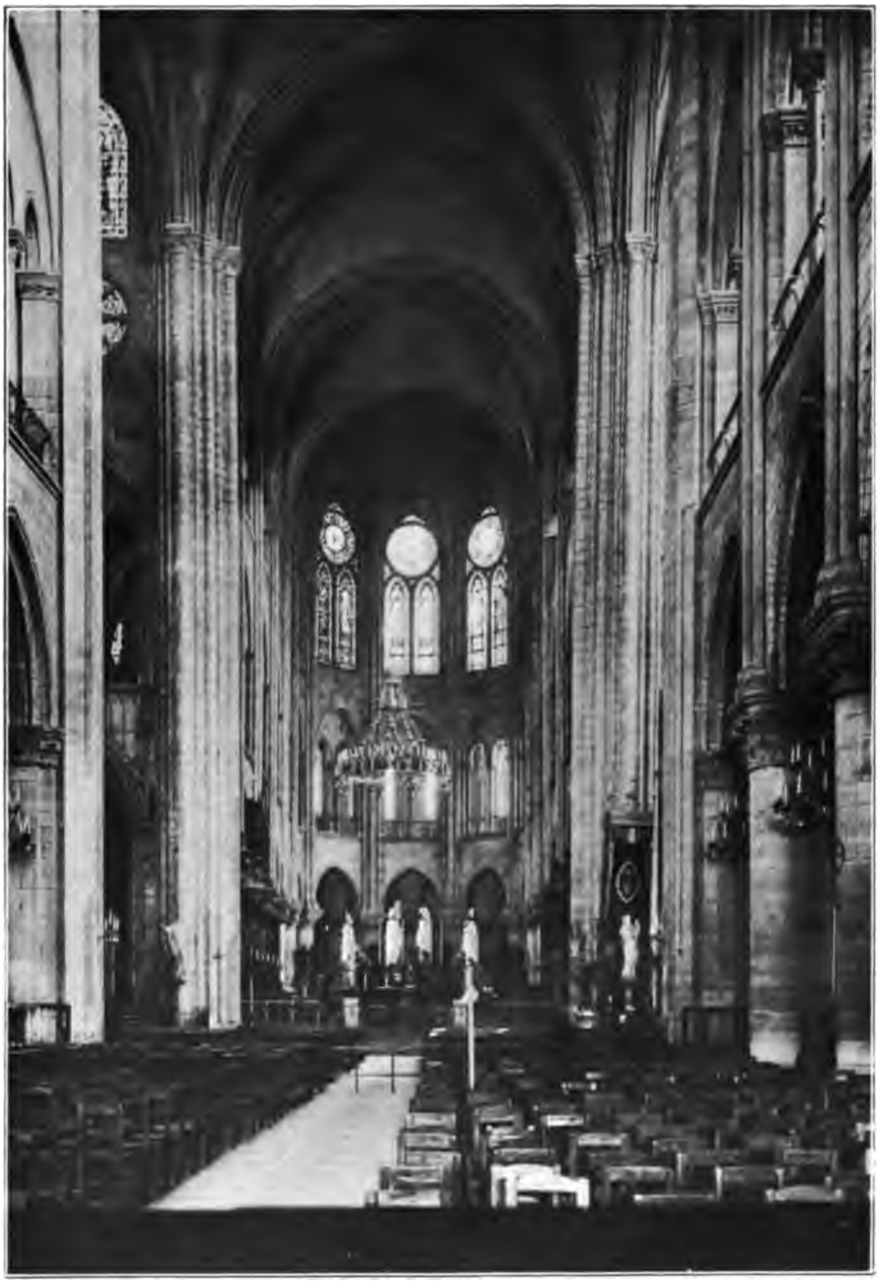
68 Vertical curves of the nave, from the right side of the organ gallery.

69 Vertical curves of the choir. From the centre of the choir gallery. Two plumb-lines are suspended from the capital of the gallery column in the centre of the picture.



64. NOTRE DAME, PARIS. PIER AND VAULTING SHAFT.
LOOKING UP THE PIER.

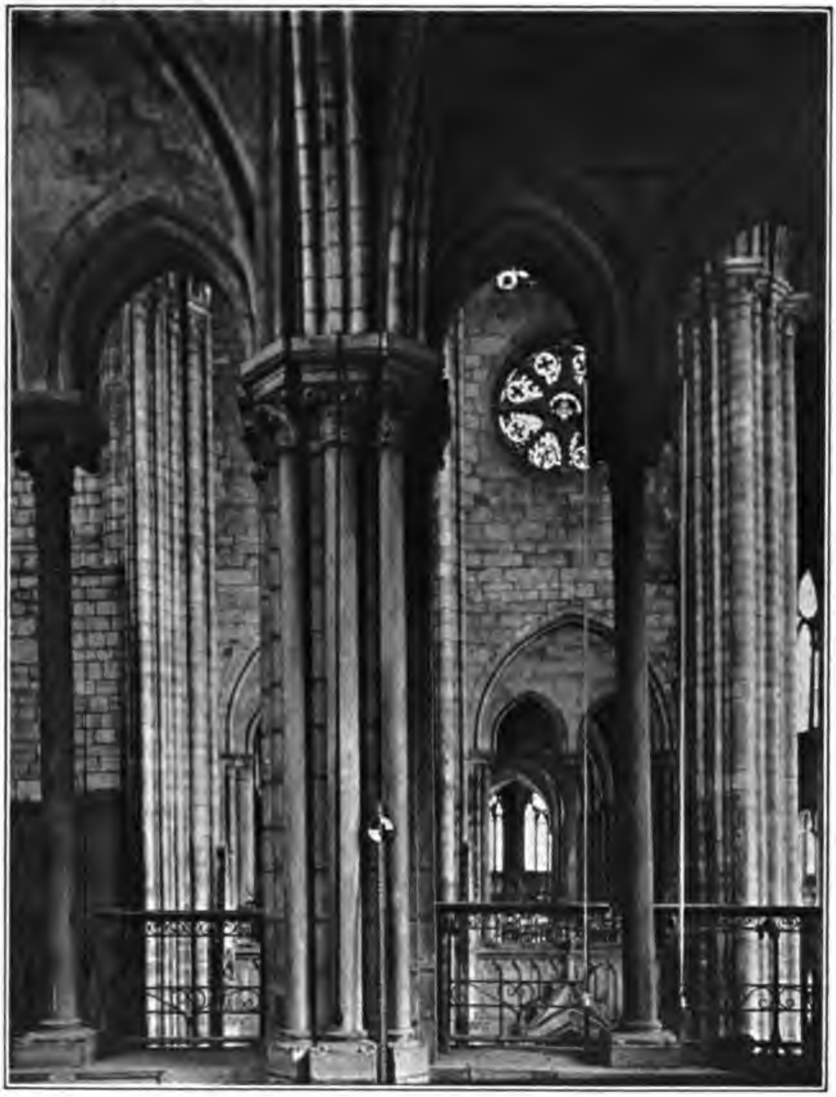
70 Vertical curves of the choir. From the right side of the choir gallery. Two plumb-lines are suspended from the capital of the gallery column, on the right of the picture.



65. THE NAVE OF NOTRE DAME.

Sympathetic Leans in the Transept Vaulting Shafts and Gallery Columns.

The gallery columns of Notre Dame which face on the transepts are set with leans corresponding to those of the crossing piers.



72. NOTRE DAME. LEFT TRANSEPT GALLERY, LOOKING TOWARD THE CHOIR.

Similar arrangements have already been illustrated for the triforium columns at Amiens and at St. Quentin. All possible doubt as to constructive facts is removed by the existence of the same arrangements in the vaulting shafts which rise from the piers and which form portions of the solid transept walls above the galleries.

71 View from the left (north) gallery across the transept. Four plumb-lines; surveyor's rod. The columns and piers are set leaning to the left, parallel with the leans of the great piers at the

crossing. (Compare No. 73 for the right gallery.) The pier on the left of this view is seen in the centre of No. 72. Plumbed with a line of ten and a half feet, the leans are as follows, from left to right in foot decimals.

Pier (two sides) .14.14 : columns, .24, .20 : pier, .10. All leans to the left.

72 View from the left (north) gallery across the transept. Four plumb-lines; surveyor's rod (six feet). Columns and piers are set leaning to the left. The leaning vaulting shafts on the farther side of the transept are portions of the solid wall. (Compare 74).

The only leans not quoted for the preceding number are those of the two columns on the left. These are .12 and .13.

As shown by the photographs there are two bays in each transept gallery. Thus in each gallery there are eight plumb measures to be quoted; one for the pier at the nave, one for the pier at the end of the gallery, two for the intervening pier (one for each side) and four for four columns, two in each bay.

The complete list of plumbs in the left transept gallery (illustrated by the two preceding photographs) is given below; taken with a line of ten and a half feet; measures in foot decimals, quoted from left to right; all leans to the left.

Pier, .15 : column, .12 : column, .13 : pier, .14 ; .14 : column, .24 : column, .20 : pier, .10.

Plumbs in the left transept gallery of the choir (bays opposite to those in Nos. 71, 72); quoted from left to right (facing the choir); all leans to the left.* In the choir each bay has only one column.

Pier, .08 : column, .03 : pier, .05 ; .03 : column, .05 : pier, .10.

Plumbs in the right transept gallery of the nave; all leans to the right.

Pier, .06 : column, .15 : column, .20 : pier, .10 ; .10 : column, .04 : column, .09 : pier, .10.

Plumbs in the right transept gallery of the choir (bays opposite to those in Nos. 73, 74); quoted from left to right, facing the choir; all leans to the right.

Pier, .10 : column, .12 : pier, .10 ; .12 : column, .20 : pier, .15.

73 View from the right (south) gallery across the transept. Three plumb-lines; surveyor's rod. The columns and piers are set to lean to the right, parallel with the leans of the great piers at the crossing.

Plumbs from left to right, line of ten and a half feet.

Pier, .06 : column, .15 : column, .20 : pier, .10 ; .10 : column, .04; column, .09: pier, .10.

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*The plumbs are quoted in this way as though taken on the outside in order that they may appear in the order of the plumbs previously quoted.

74 Leaning columns of the adjacent bay. The four plumb-lines are not only available for illustration of the inclination of the columns. They are especially important as fixing the alignment of the vaulting shafts which are portions of the solid wall on the opposite side of the transept.

The leans of the columns are .04 and .09. The counterpart view for the left gallery is No. 72.

The leans shown by the vaulting shafts in Nos. 73 and 74 are carried out into the transept walls but accurate observations have still to be made here.

It must be remembered that the measurements above quoted for the piers (as distinct from the columns) represent only a fraction of their entire height—as appears by observation of the farther, exterior, side of the transept in the photographs. For the entire height from pavement to vaulting the leans must be estimated as averaging about one foot. What shows as a "pier" in the interior of the transept galleries is a portion of a vaulting shaft which rises from the pier below to the top of the clerestory.

The philosophy of the sympathetic leans illustrated by Nos. 71-74 is considered under No. 9 and under No. 62. Here, as in the window leans of Notre Dame, Nos. 99, 100, the motive must be to evade detection, or an over-conspicuous prominence, of the primary leans, which, in the instance of 71-74, are those of the great piers of the crossing.

Curves in Plan.

The deflection in plan of the choir of Notre Dame, which bends to the left, is represented in published plans of the church,* but the curves in plan of the aisles and galleries are not represented in these published plans, as far as known to the writer. It is positive that the curves represented in the photographs of the galleries begin in the aisles below. A more accurate survey of the ground-plan of Notre Dame than has yet been published is much to be desired.

75 Left (south) gallery, looking toward the choir. View showing its curve in plan convex to the nave; which amounts to nine and a half inches at the point marked by the surveyor's rod. The outer wall of the gallery has a parallel curve. This curve is also visible in the vaulting. The left gallery has a parallel curve, concave to the nave, but more pronounced in the gallery parapet than in the wall. These curves begin in the lower aisles but are more easily photographed in the galleries. In the galleries they are similar to those found in the Pisa Cathedral and in some other Italian

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*Lassus et Viollet-le-Duc. Monographie de Notre Dame de Paris.

churches. Compare also Nos. 31, 32, for St. Pierre at Caen and No. 33 for St. Ouen at Rouen. For the philosophy and derivation of such curves in plan consult the bibliography on the second page of the cover.

The plumb-line suspended from the second pier on the left shows that the gallery piers are closely perpendicular and that the vertical curves on the opposite sides of the gallery piers, facing the nave, are not due to thrust. See Nos. 67, 68.

76 Curve in plan of the exterior clerestory wall above the gallery piers shown by No. 75. There is a corresponding curve in this wall and in the alignment of the buttresses. This curve is repeated in the bend in the line of the roofing slabs which are shown by the photograph.

77 Curve in plan of the left (south) gallery; looking toward the façade; the same gallery curve which is illustrated by No. 75, photographed in the opposite direction. The piers are again seen to be perpendicular, although the vertical curves seen in Nos. 67 and 68 are found on their exterior faces.

Gallery Bends in Elevation.

78 Bend in elevation of the left (north) gallery, photographed from the choir gallery. There is a corresponding bend in the capitals of the gallery columns and piers.

Beginning at the pier beyond the organ the gallery parapet* rises 0.95 in the first three bays. (This portion of the bend is shown in much larger scale and much more clearly by Nos. 88, 89, 90.) It then continues with an additional rise of 0.08 to the transept. On account of the obstruction caused by the scaffolding and benches in this gallery, the measures quoted were established by plumbs taken from the parapet to the pavement below, and the level of this pavement was not taken, but in the opposite (south) gallery similar facts were established by a levelling instrument which was used in the gallery.

79 Bend in elevation of the right (south) gallery, photographed from the choir gallery. The capitals of the gallery columns and piers follow this bend. It is also repeated in the gallery windows. (Compare No. 77.) The bend is also repeated in the alignment of the sills in the clerestory windows. Compare No. 94 where the obliquity is shown in larger dimension. Levels taken in the south gallery show a rise in the first three bays of 0.85 and a drop for the last five bays toward the transept of 0.28. Reference is again made to Nos. 88-90, as larger and better illustrations of these bends.

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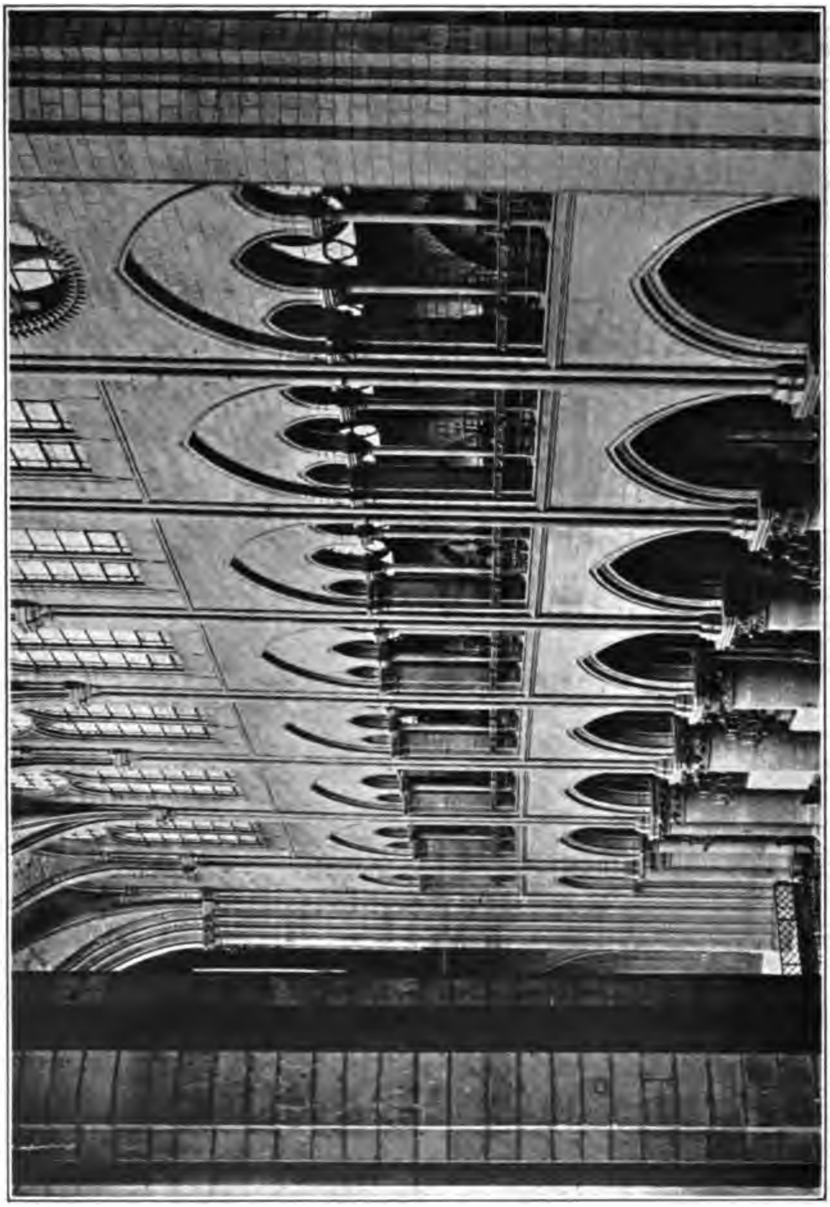
*The measures and levels were taken for the parapets. The pavement corresponds but may vary slightly from description given.



78. NOTRE DAME. LEFT (NORTH) GALLERY. FROM THE CHOIR.

The gallery bends of Notre Dame are so closely analogous to those of the Pisa Cathedral that great stress must be laid upon the resemblance. The latter were surveyed with great accuracy in 1895, and the original cartoons of survey are herewith reproduced.

80 The original surveys of the gallery bends of the Pisa Cathedral
81 were first published in the Architectural Record, Vol. VI., No. 3.
"Constructive Asymmetry in Mediæval Italian Churches."

In both cathedrals the bends are wholly invisible from the pavement of the church, as they are discounted into optical effects. These effects are undoubtedly those of an illusive exaggeration of perspective. It is beyond debate that perspective illusions of other descriptions were practiced by mediæval builders (Arch. Rec. Vol. VI., No. 2. See also the reference to Fergusson under No. 11 of this catalogue). It would be unwise to assert that an exaggerated perspective was the only purpose of these bends, but there are grounds for believing that it was designed to be one of the results. Another motive was probably the avoidance of monotony and formalism.

82 Diagram in elevation of the piers, gallery, and clerestory walls of the north side of Notre Dame in exaggerated drawing. To be used in connection with photographs 78-79 and 83-98 inclusive. The most remarkable arrangements in Notre Dame have now to be described and illustrated. All the columns[*] of both galleries of the nave are set with leans which are so arranged as to exaggerate the effect of the gallery bends.

For the five bays in which the galleries drop toward the transept, or are approximately level, the columns lean toward the façade. (Nos. 83-87.)

For the three bays in which the galleries rise (.95 north; .85, south); the columns lean toward the choir. (Nos. 88-90.)

On the other hand the vaulting shafts[†] and the gallery piers which are portions of the vaulting shafts lean toward the façade beginning at the transept, and without exception, up to the façade (diagram No. 82).

Hence, in the three bays nearest the organ gallery the vaulting shafts bend away from their normal lean below the galleries, in order not to antagonize too perceptibly the leans of the gallery columns and these vaulting shafts return to their normal lean by another bend above the gallery columns. (Diagram 82, photographs 89-93 and 97.)

These arrangements are found on both sides of the church, and

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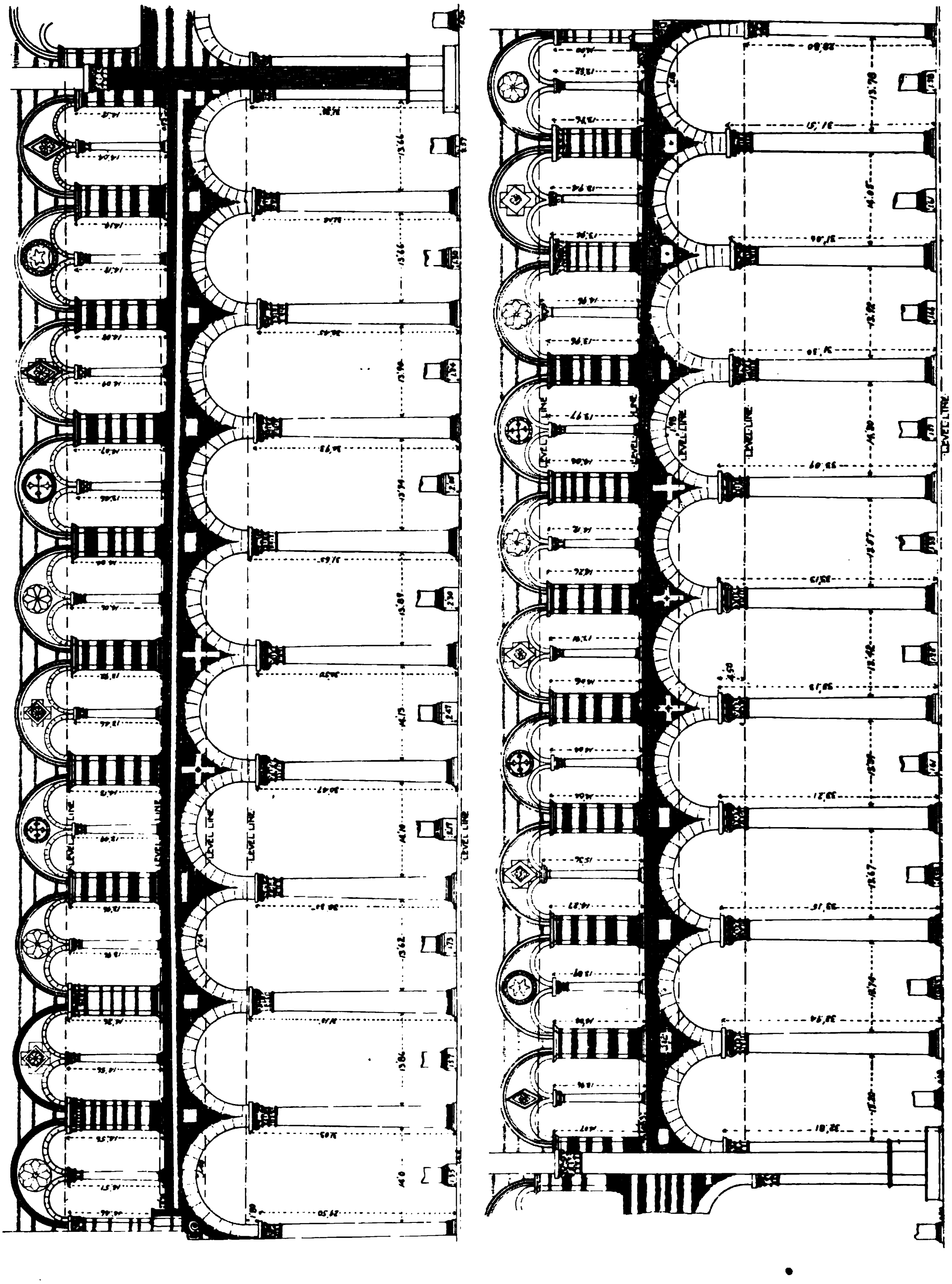
[*] The gallery columns are to be distinguished from the gallery piers. The former are round and monolithic; the latter are square and built of masonry, and are portions of the vaulting shafts which rise from the piers of the nave.

[†] The vaulting shafts are the continuation of the piers of the nave, but as they are attached to the clerestory wall and are therefore not subject to thrust in east or west direction, unusual significance attaches to their leans, because they are uniform in direction and therefore clearly intentional.



80, 81. PISA CATHEDRAL. SURVEYS OF THE GALLERY BENDS IN ELEVATION.

are verified by measurements in detail for each column and each pier in both galleries, as follows:

Plumbs for Gallery Piers and Columns.

North Gallery.		South Gallery.
.10W	*Pier at Transept	.04W
.05W	1st Bay Column	.03W
.10W	1st " "	.04W
.04W	2nd Pier	.06W
.10W	2nd Bay Column	.07W
.12W	2nd " "	.14W
.05W	3d Pier	.07W
.06W	3d Bay Column	.14W
.11W	3d " "	.15W
.05W	4th Pier	.07W
.06W	4th Bay Column	.13W
.07W	4th " "	.13W
.05W	5th Pier	.06W
.04W	5th Bay Column	.13W
.05W	5th " "	.11W
.05W	6th Pier	.05W
.04E	6th Bay Column	.20E
.00	6th " "	.03E
.10W	7th Pier	.05W
.18E	7th Bay Column	.25E
.24E	7th " "	.12E
.03W	8th Pier	.03W
.14E	8th Bay Column	.10E
.20W	9th Pier	.14W

*Leans are marked east or west, i. e., toward choir, or toward façade. Length of line, 10¼ feet.

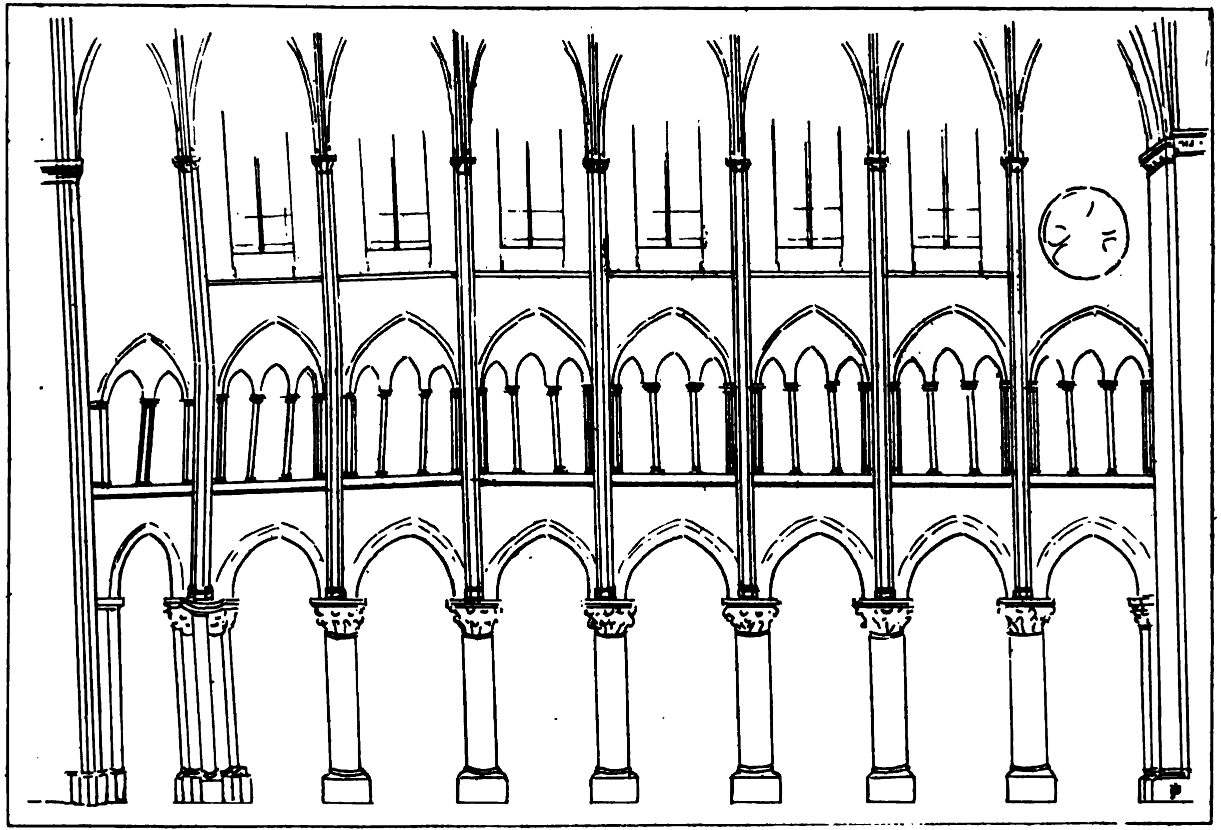
If these plumbs are now grouped separately by piers and columns the comparison will prove less confusing and the results of this comparison will be more quickly reached.

Plumbs for Gallery Piers, Omitting Columns.

North Gallery.		South Gallery.
.10W	Pier at Transept	.04W
.04W	2nd Pier	.06W
.05W	3d Pier	.07W
.05W	4th Pier	.07W
.05W	5th "	.06W
.05W	6th "	.05W
.10W	7th "	.05W
.03W	8th "	.03W
.20W	9th " at Organ Gallery	.14W

It appears from the above plumbs that all vaulting shafts of the nave lean west (toward the façade) in measurements which are of small amount for the length of plumb-line used for the gallery piers but which are of considerable amount when the height from the pavement to the vaulting is considered.

The leans of the nave piers from which the vaulting shafts rise will be subsequently described and illustrated.



82. ELEVATION, IN EXAGGERATED DRAWING, OF THE NORTH SIDE OF NOTRE DAME.

The minimum amount of lean in any one pier and connected vaulting shaft cannot be less than six inches for the height from pavement to vaulting. This appears to be the average for the first seven, beginning with the transept piers. The 8th pier leans from pavement to capital 0.37 in twenty feet (No. 97). The plumb .03 in the gallery represents the reverse bend of the 8th vaulting shaft as already described and explained. It subsequently returns to the amount of pitch measured below. The three piers nearest the façade (9th, 10th, 11th) lean 0.44 in twenty feet from the pavement.

The details regarding the estimates for these leans are more fully given under Nos. 94-100 inclusive.

From the standpoint facing the choir the effect of these leans is to exaggerate the appearance of widening without that detriment to stability which might be anticipated from too pronounced constructive divergence. This may have been one of the motives for this construction. That much stress was laid upon it is apparent from the remarkable efforts to compromise between the leans of the vaulting shafts and those of the triforium columns as shown by Nos. 89, 90, etc.

The increase of pitch toward the façade tends to negative the view that the leans toward the façade were purely sympathetic with the transept widening, which is of very slight amount.

The plumbs for the gallery columns are now separately recorded. The evidence of design which is obtained from the correspondence of inclination on opposite sides of the church, is unimpeachable. The change in direction on both sides of the church between the 5th and 6th bays can only be explained by the wish to exaggerate the effect of the gallery bends, as seen from below.

Plumbs for Gallery Columns, Omitting Piers.

North Gallery.		South Gallery.
.05W	1st Bay	.03W
.10W	....	.04W
.10W	2nd Bay	.07W
.12W	....	.14W
.06W	3d Bay	.14W
.11W	....	.15W
.06W	4th Bay	.13W
.07W	....	.13W
.04W	5th Bay	.13W
.05W	....	.11W
.04E	6th Bay	.20E
.00	....	.03E
.18E	7th Bay	.25E
.24E	....	.12E
.14E	8th Bay	.10E

The Eight Bays of the South Gallery.

Each bay of the south gallery was separately photographed with plumb-lines on both sides of each column. The plumb-lines were, strictly speaking, broad tapes, such as were generally used throughout the trip for such purposes. It was though desirable to use such tapes in order that the width might give them greater prominence in the pictures. There were some disadvantages in these lines. It was not possible to prevent them from turning slightly so that the broad side appears sometimes only in one part of the line and the narrow edge in another. Occasionally the tapes became so twisted and uneven from constant use that they did not stretch properly with the light plumb-bobs which were attached to them. It will be noticed that some of the tapes do not hang perfectly true. However, as the plumbs already recorded were all taken with a light cord and a heavy plumb-bob the measures may be regarded as sufficiently satisfactory and they make good an occasional distortion of the tape lines in those pictures. The plumb-lines are of great value not only for the foreground columns but also as verifying the leans of columns and vaulting shafts on the opposite side of the nave. The photographs for the eight bays of the south gallery, which have been already quoted in mass, are now individually mentioned in order from the transept to the organ gallery.

83 First bay. All leans to the left. Columns, .04 : .03. Piers, .06 : .04.*

84 Second bay. All leans to the left. Columns, .14 : .07. Piers, .07 : .06.

The plumb-lines also verify the columnar leans in the opposite gallery. From the column which leans .14 one may sight the leaning vaulting shaft on the opposite wall up to the height of the vaulting. From the left plumb-line on the column leaning .07 one may sight the vaulting shaft opposite up to the vaulting.

85 Third bay. All leans to the left. Columns, .15 : .14. Piers, .07 : .07. The leans of the vaulting shafts are well shown on the opposite wall up to the clerestory.

86 Fourth bay. All leans to the left, in the foreground. Columns, .13 : .13. Piers, .06 : .07. The inclination of vaulting shafts across the nave can be sighted both by the lines and by the columns in the foreground.

87 Fifth bay. All leans to the left, in the foreground. Columns, .11 : .13. Piers, .05 : .06. The vaulting shafts of the opposite clerestory may be sighted as usual.

88 Sixth bay. All leans of columns to the right (excepting in the

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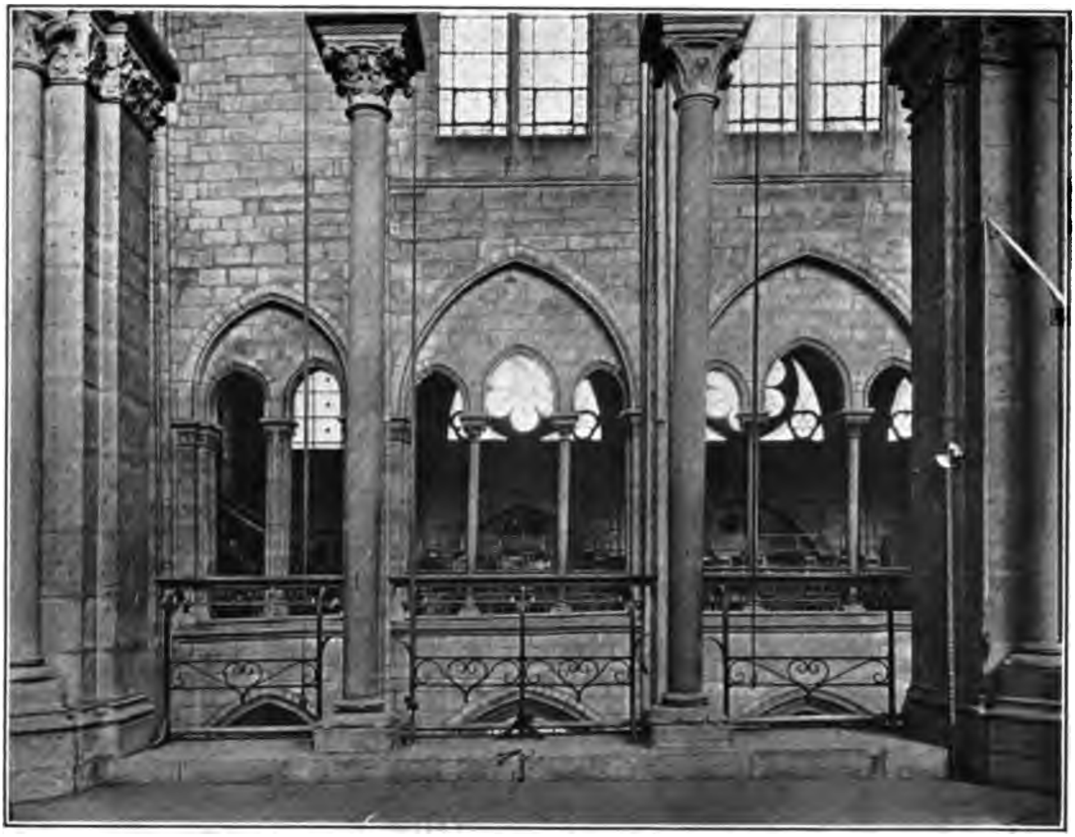
*The left column and left pier are the first ones quoted throughout these bays.



89. SOUTH GALLERY, NOTRE DAME. SEVENTH BAY, COUNTING FROM THE TRANSEPT.

right bay across the nave which is the fifth bay on that side, so that the column there seen leans to the left. All piers lean to the left. Columns, .03 : .20. Piers, .05 : .05. The vaulting shafts of the opposite clerestory may be sighted as usual.

The north gallery bend in elevation is well shown. The rise of the parapet in the foreground is also visible.

89 Seventh bay. All columns lean to the right, all piers lean to the left. Columns, .12 : .25; Piers, .03 : .05: This photograph shows the north gallery bend, the rise of the parapet in the foreground, and the change of inclination in one of the vaulting shafts on the north side of the church, as shown by exaggerated drawing in No. 82. (One column perpendicular on north side. See Table.)

90 Eighth bay.* Column leans to the right, .10. Piers lean to the left, .14† : .03. The rise of the parapets is seen on both sides. The

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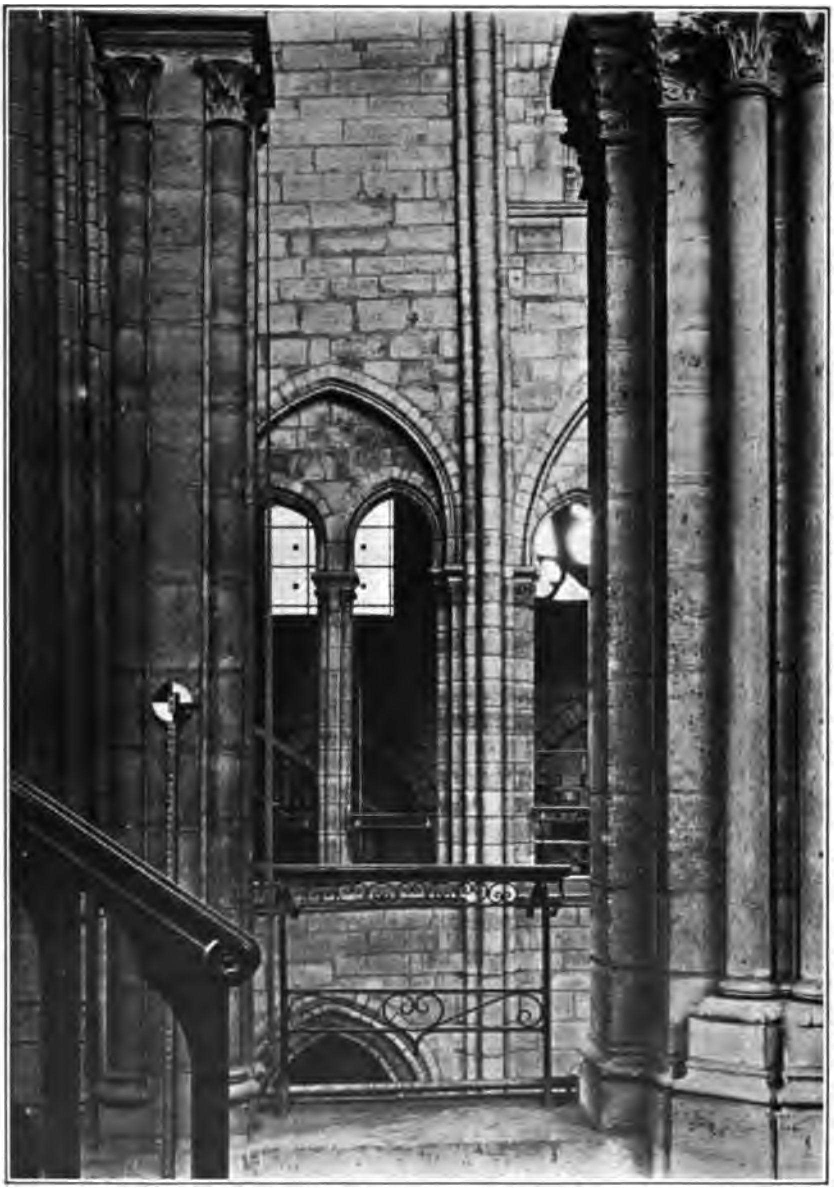
*A small pier here takes the place of the column, but we will specify it as a column in order to preserve the uniformity of statement.

†This outer ninth pier could not be included in the picture.



90. SOUTH GALLERY, NOTRE DAME. EIGHTH BAY, COUNTING FROM THE TRANSEPT.

strong pitch of the great pier across the nave (9th pier) is well shown on the extreme left of the picture.

91 Wide-angle view from the same bay, with camera placed near the railing. Two plumb-lines suspended from the bay opposite.

The columns opposite lean to right as follows: eighth bay, .14; seventh bay, .24; .18.

The eighth pier (on the right of the picture) leans to the left from pavement to capital 0.37 in a height of twenty feet. The vaulting shaft which rises from it so changes direction at the gallery (to avoid contrast with columnar leans to the right), that it only leans .03 in ten and a half feet. At the capitals of the gallery it again changes direction, turning to the left. Above this point it is seen to be parallel with the great pier next the organ loft which leans .20 west in ten and a half feet at the gallery and which has a nearly uniform pitch from the pavement up to the vaulting.

Views Across the Nave from the North Gallery.

92 Eighth bay of the north gallery. Piers lean to right, .03 and .20. Column leans to left, .14. The vaulting shafts on the opposite side of the nave are well shown.

93 Wide-angle view from the same bay, with camera placed near the railing. A plumb-line is hung from the opposite parapet. This view is the counterpart of 91 and shows that the same arrangements are found in both galleries. The bend of the 8th vaulting shaft, to compromise with the columns leaning to the left, is less pronounced but is quite definite. The column in the eighth bay leans one-third less on this side. It leans .10, whereas the corresponding column in the north gallery leans .14. This would explain the less pronounced change of direction in the vaulting shaft.

The rise in level of the parapet is well shown. The window-sill of the clerestory rises at the same angle.

94 Sixth and seventh bays of the south gallery, from the north gallery. A plumb-line is hung from the clerestory window. The estimate based on the deflection of the vaulting shaft from this plumb-line would make the entire amount of lean from pavement to vaulting about eight inches in a height of about eighty-two feet, provided the lean were continuous. The plumbs from the pavement to the height of the capitals tend to diminish this estimate in some cases. An average estimate for the westward leans of the piers and connected vaulting shafts for the first seven bavs from the transept will therefore be from six to eight inches. The eighth and ninth piers are already noted for more pronounced leans (which continue in the tenth and eleventh piers, as shown later).

A highly important feature of this photograph is the obliquity of the string-course which marks the line of the window-sills in the clerestory. This obliquity corresponds to the gallery bend below, also shown in this picture. The bend in the line of clerestory window-sills is also shown by No. 79.

The columns lean to the left; plumb measurements under Nos. 88 and 89.

95 Fifth and sixth bays of the south gallery, from the north gallery. A plumb-line suspended from the clerestory window furnished the basis for an estimate of the lean of the adjacent vaulting shaft corresponding to that which has been given under the preceding number.

The columns of the fifth and sixth bays are seen to be leaning in opposing directions. The fifth bay columns lean west, .13 and .11. The sixth bay column leans east, .20.

The bend of the gallery parapet is repeated in the string-course of the window sills in the clerestory.

Westward Leans in the Nave.

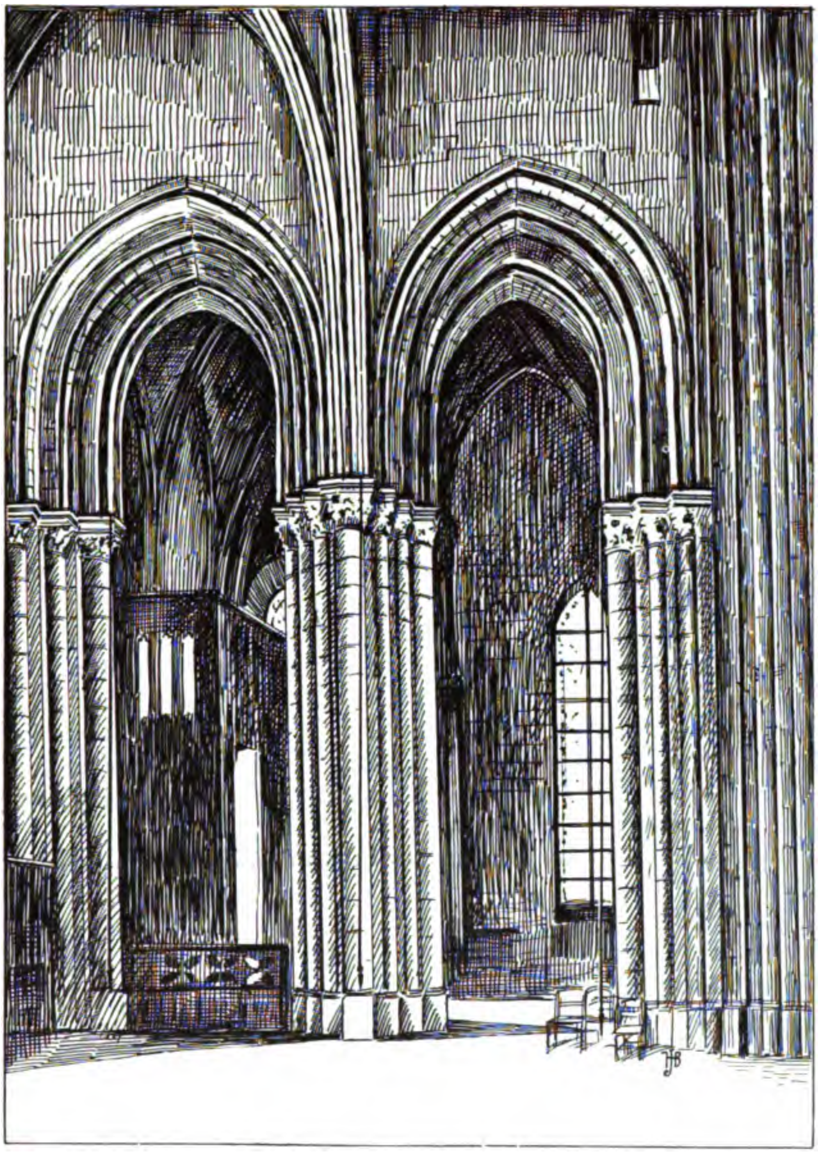
96 Details of leaning pier in the nave, third from the organ loft on the north side of the nave. It is the seventh pier in the order from the transept. A plumb-line is hung on the right side with slips of white paper at top, center and bottom, to show its direction in the photograph. By plumb from the capital the lean toward the façade is .14 (line of twenty feet). All piers of the nave were plumbed to the height of the capitals with similar results. The leans diminish toward the transept. The quotations for the remaining piers on the north side are as follows in the direction toward the transept, .09; .08; .08; .05 (transept pier not taken).

The leans would be too inconsiderable for attention, were it not for four facts. First, they are continuous from pavement to vaulting and as found in the vaulting shafts which are attached to the clerestory wall are wholly free from suspicion of thrust.

Second, they are uniform in direction. Third, they increase above the capitals as shown by gallery measures. Fourth, they increase in the direction of the façade and are there related to sympathetic leans in windows and engaged pilasters which demonstrate constructive intention beyond debate.

In the less pronounced cases the leans may average six inches from pavement to vaulting, but in the piers of the tower construction toward the façade they amount to five inches in a height of twenty feet.

The lowest cylindrical section of the pier shown by No. 96 is cut to a dip of .08 in a diameter of 5.20. In other words, this drum, or section, has a height of .46 on the left and a height of .38 on the right side.



98. NOTRE DAME. VIEW ACROSS THE NAVE FROM SOUTH TO NORTH; NEAR THE FAÇADE. ACCURATE DRAWING FROM THE SURVEY PHOTOGRAPH.

97 View crossing the nave from south to north near the façade. Two plumb-lines are suspended from the gallery. The piers are the eighth and ninth from the transept. The left pier is the one next the organ gallery (tower construction). The lean of the right pier up to the height of the capital amounts to 0.37 in twenty feet.

This view connects with No. 91 for the upper part of the church.

98 View crossing the nave and connecting with 97, showing the piers next the entrance. Plumb-lines are hung from the piers on the left and right. The leans average 0.44 in twenty feet.

The window and the engaged pilaster on its left, are constructed with parallel, sympathetic, leans. The same facts are found on the opposite side of the nave for the corresponding windows and engaged pilaster on that side.

99 Details of 98. Windows, and two engaged pilasters showing
100 constructive leans. Two plumb-lines; surveyor's rod on the right. For the philosophy of these sympathetic leans and for other illustrations of them see No. 9 for St. Loup at Chalons and No. 62 for Amiens Cathedral.

The Leaning Facade and the Vertical Bends of the Towers.

101 Diagram of the north tower of Notre Dame, showing the construction which is illustrated by Nos. 102-106.

102 The leaning windows of Nos. 99 and 100, seen from the outside.

103 The tower buttresses lean to the right. The perpendicular is established by a plumb-line hung on the railing; surveyor's rod beside it.

104 The leaning lower façade of Notre Dame. Plumb-line from the Gallery of Kings. The lean amounts to about eleven inches in about forty-eight feet, up to the height of the Gallery of Kings, as reckoned for any one continuous surface. The façade bends to the perpendicular higher up. For an account of other leaning and bending façades see Memoir No. 1.

105 Views showing the return bend of the towers to the perpendic-
106 ular.

107 Leaning façade of the south transept. The perpendicular is established by a line from a tripod. In the north transept the lean is much less pronounced but it appears to exist.

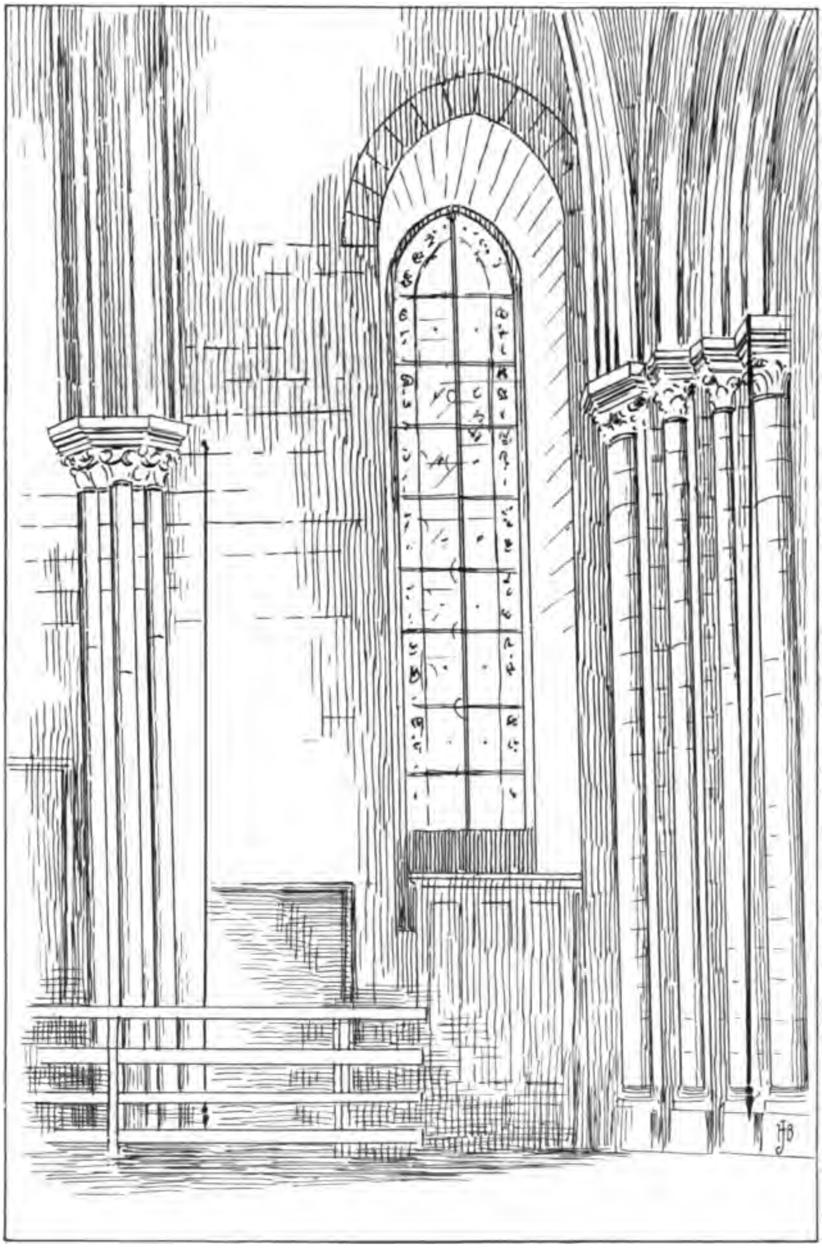
Bends in Plan of the Facade.

108–109 Views of the façade showing the Gallery of Kings.

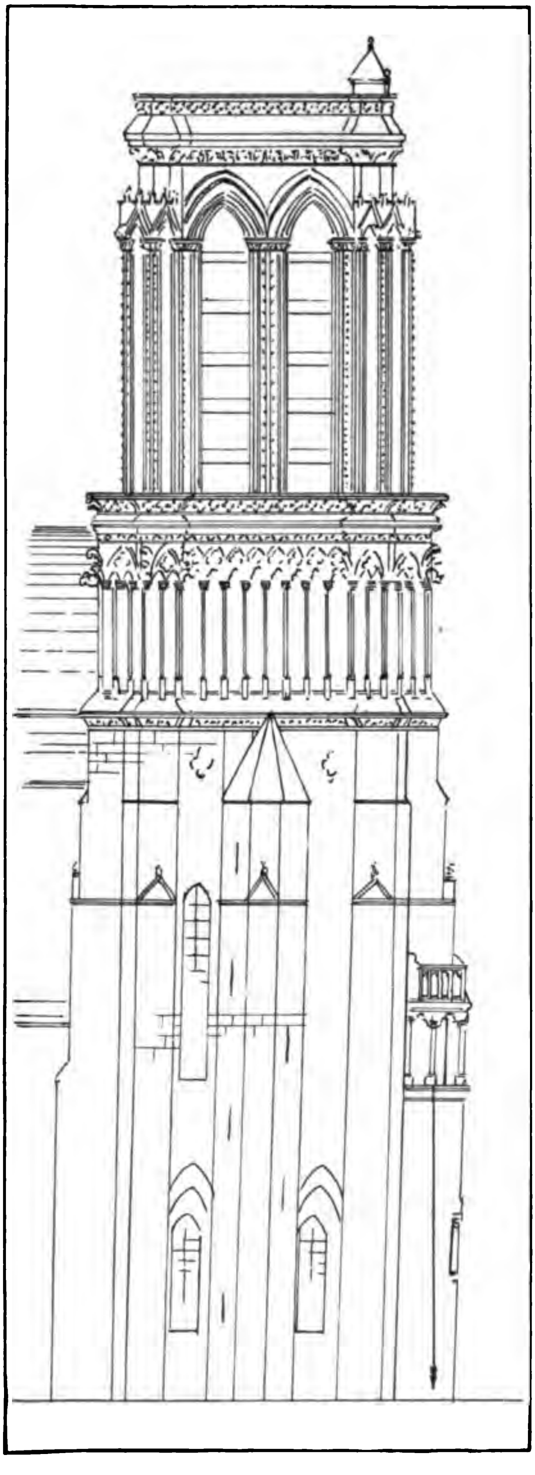
110 Bend in plan of the Gallery of Kings. The forward deflection is 1.20 feet. This bend is repeated in both upper galleries.

111 View showing bends in elevation in the upper galleries of Notre Dame which are an optical effect produced by the bends in plan. This arrangement breaks the monotony of the straight line.

According to well known principles of optics the bend in plan will produce the appearance of a bend in elevation of a corresponding amount, at an angle of 45°. In closer proximity the optical effects increase. It follows, that, for a spectator walking towards Notre Dame, these bends are continually changing their appearance.



100. LEANING WINDOW AND LEANING ENGAGED PILASTERS. LEFT AISLE OF NOTRE DAME, NEAR THE ENTRANCE. ACCURATE DRAWING FROM THE SURVEY PHOTOGRAPH.



101. VERTICAL BEND OF THE NORTH TOWER OF NOTRE DAME. EXAGGERATED DRAWING.

Conclusions as to Notre Dame.

It is apparent that Notre Dame occupies a very exceptional position among the French cathedrals described in this Memoir as regards the variety and subtlety of its constructive variations from normal regularity. Among Italian churches it can only be compared with the Pisa Cathedral and St. Mark's at Venice, for the number and subtlety of its refinements.

The nave piers leaning uniformly west in the direction of the façade are otherwise so far known only in St. Mark's (see Plan 3 for plumbs, Memoir No. 2).[*]

The only other churches in Europe which are known at present to have the horizontal gallery bends in elevation are the Pisa Cathedral[†] and St. Mark's at Venice. The analogy with the Pisa Cathedral is much the most striking as the galleries are shorter in St. Mark's and the treatment is quite different.

As regards vertical bending of the west façade it has not been so far observed in any other French church excepting Notre Dame la Grande at Poitiers, where it is relatively inconspicuous, St. Nicholas at Coutances, a church of minor importance, and the Sainte Chapelle at Paris. In this matter the most important analogy is again offered by the Pisa Cathedral (Memoir No. 1, and Arch. Rec., Vol. VII., No. 3).

(There are good survey photographs of the front porch of the Sainte Chapelle which have not been enlarged. It leans out about one foot in a height of about thirty-eight feet, with return curve to the perpendicular. There are no refinements in the interior.)

The vertical bends of the towers of Notre Dame are not known at present to have any parallels and the same may be said of the bend in plan of the west façade.

Deflected choirs are not uncommon in Northern Europe, but these must be distinguished from curves in plan of the gallery parapets or of alignment in the piers of the nave. Notre Dame is the only cathedral in France which has been so far observed to possess the gallery curves in plan. The following cathedrals appeared to have wholly normal plans, as regards horizontal curves and as regards deflected choirs; Mont St. Michel, Dol, Coutances, St. Lo, Bayeux, Lisieux, Evreux, Chartres, Rouen, Amiens, Beauvais, Laon, Noyon, St. Quentin, Rheims, Chalons, Soissons,

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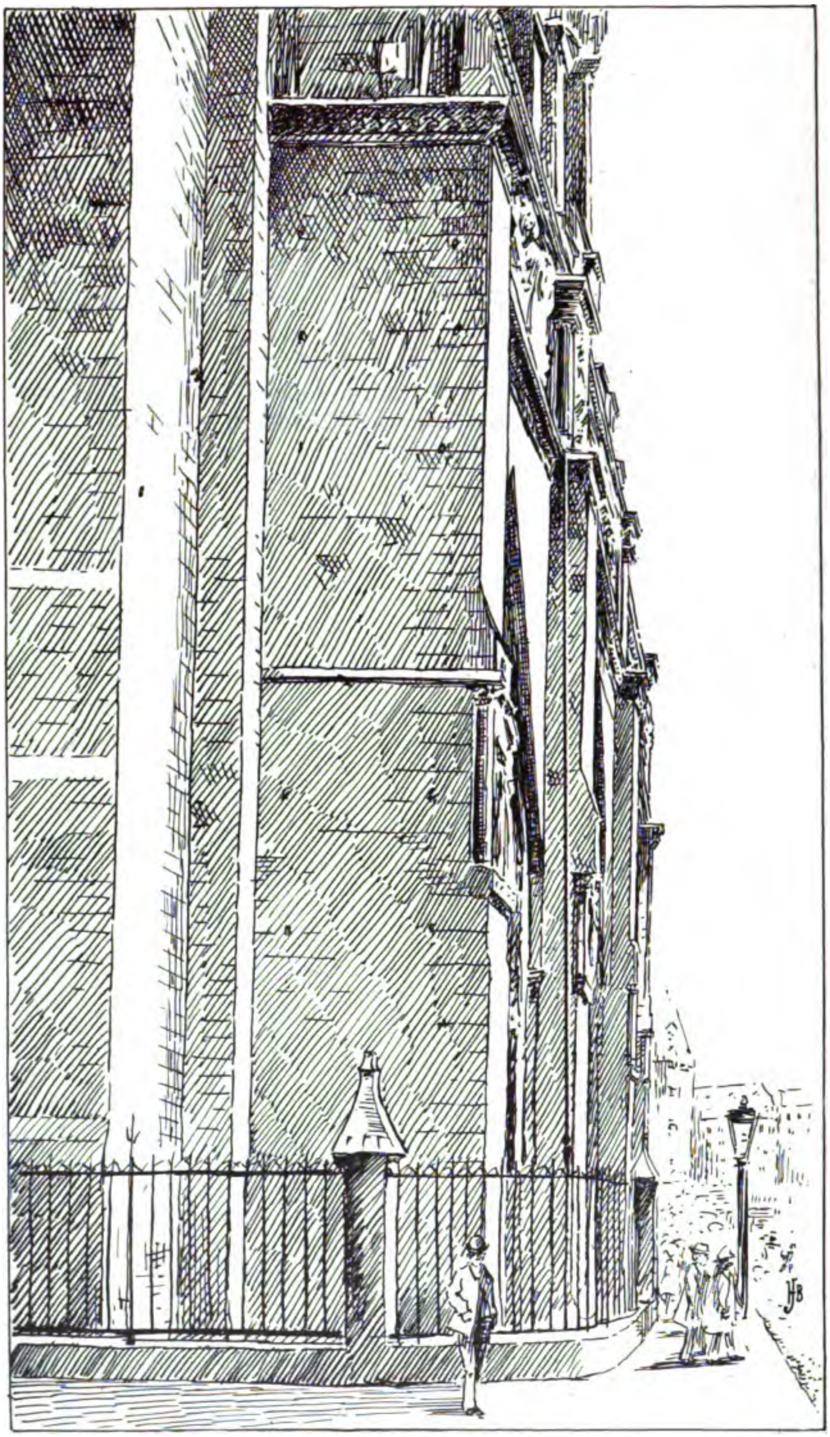
[*] And in the church of the Madonna dell' Orto, at Venice. In this church the columns (not piers) were noticed in 1895 as all leaning toward the façade, from 4 to 7 inches. The church also has a leaning façade which curves to the perpendicular. No publication has been made regarding this church because no measures or photographs were taken. It cannot be said at present that the leaning columns in the church of the Madonna dell' Orto are not so inclined by accidental causes.

[†] The mention in Arch. Rec., VI., 4, p. 502, of the Cremona Cathedral as having this construction is an error. In 1895 the observation to this effect was made from the openings in the clerestory, but in 1901, when photographs were taken from the same position, it appeared that the effect of the bend in elevation was produced by a bend in plan.



104. THE LOWER LEANING FAÇADE, NOTRE DAME. ACCURATE DRAWING FROM THE SURVEY PHOTOGRAPH.

Angoulême and Strassburg. The closest analogy known, as regards the gallery curves in plan, is again offered by the Pisa Cathedral, although a number of Italian cathedrals and churches can be quoted for similar deflections.

Observations have been made in some one hundred and twenty Italian churches and in some thirty-three French churches for various individual refinements and for the combination of several, but it thus appears that Notre Dame, the Pisa Cathedral, and St. Mark's at Venice are by far the most remarkable churches, so far known, for the systematic application and great variety of their architectural subtleties.

In the effort to explain these subtleties there can be only one point of departure. Whatever individual explanations may be offered for individual phases of asymmetrical construction, the primary fact must remain this, that many mediæval builders consciously disliked, and avoided, geometrical or mathematical regularity, and the incident monotony and mechanical formalism and coldness of architectural effect.

Since the bibliography on the second page of the cover mentions a series of publications in which the explanations of various mediæval refinements have been elaborately discussed, it will be well to limit the present discussion to that wholly original arrangement in Notre Dame (wholly original as far as these observations have been carried) which unites an interior system of westward leans in the vaulting shafts with an exterior system of westward leans and vertical bends in the towers and façade. The union of these two systems is illustrated by the diagrams Nos. 82 and 101.

It is the opinion of the writer that neither single arrangement was conditioned by the other. They were probably regarded as two good things to do, which worked in together. There are several instances of bending façades and notably that at Pisa, in which there is no such elaborate system of interior westward leans. St. Mark's shows a system of westward leans and also a bending façade, as regards the setting of the two stories of columns (Memoir No. 1), but these arrangements are separated by a broad vestibule and are not interwoven as in Notre Dame.

The view is therefore tenable, since both features are found separated elsewhere, that neither one was necessitated by the other in Notre Dame.

The final problem then remains; were the vaulting shafts leaned to the west out of sympathy with a widening in the choir, or because they increased the effect of widening in the nave, or because perpendiculars were avoided on principle by the given builders? It is useless to discuss this problem until more facts have been observed and collated, and until more cathedrals have been examined.

The widening of the transepts in Notre Dame is so insignificant* that it is difficult to conceive of an entire nave system of westward leans as having developed from it in that church. On the other hand if a certain number of earlier Romanesque monuments be found to have westward nave leans with a more pronounced transept widening, the probability would grow that westward leans in naves had originally developed as sympathetic leans, parallel with the transept widening, and that they had been continued in Notre Dame as a matter of heredity, without an impelling cause of the same strength in that church. (It must however be admitted that the vaulting shafts of the nave near the transept very closely correspond to the westward widening of the transept piers.)

NOTRE DAME LA GRANDE AT POITIERS.

112 Profile view of the lower façade. It leans forward slightly and curves toward the perpendicular. The fillets of the bases tilt upward, instead of slanting downward, as would be the appearance in case of settlement. Compare S. Michele at Pavia (Memoir No. 1).

CATHEDRAL OF BEAUVAIS.

113 Widening of the choir at Beauvais; not less than three feet; width at the pavement forty-six feet, height one hundred and forty-six feet.

114 Widening of the transepts at Beauvais; more pronounced than in the piers of the choir.

CATHEDRAL OF ROUEN.

115 Widening of the nave; estimated at fourteen inches. Height of vaulting ninety-two feet.

CATHEDRAL OF RHEIMS.

116 Vertical curves of the nave and widening, estimated at twenty-six inches; width of nave at the pavement thirty-nine and one-half feet. Height, one hundred and twenty-five feet.

CATHEDRAL OF STRASSBURG.

117 Vertical curves of the nave, with widening, estimated at twenty-two inches. Width of nave at the pavement forty-two feet. Height, ninety-nine feet.

CATHEDRAL OF CHALONS.

118 Widening of the nave. Well defined. Not estimated.

CATHEDRAL OF NOYON.

119-122 Vertical curves of the nave:

119 Wide-angle view from the organ gallery.

120 Right side of the nave from the organ gallery. The plumb-lines

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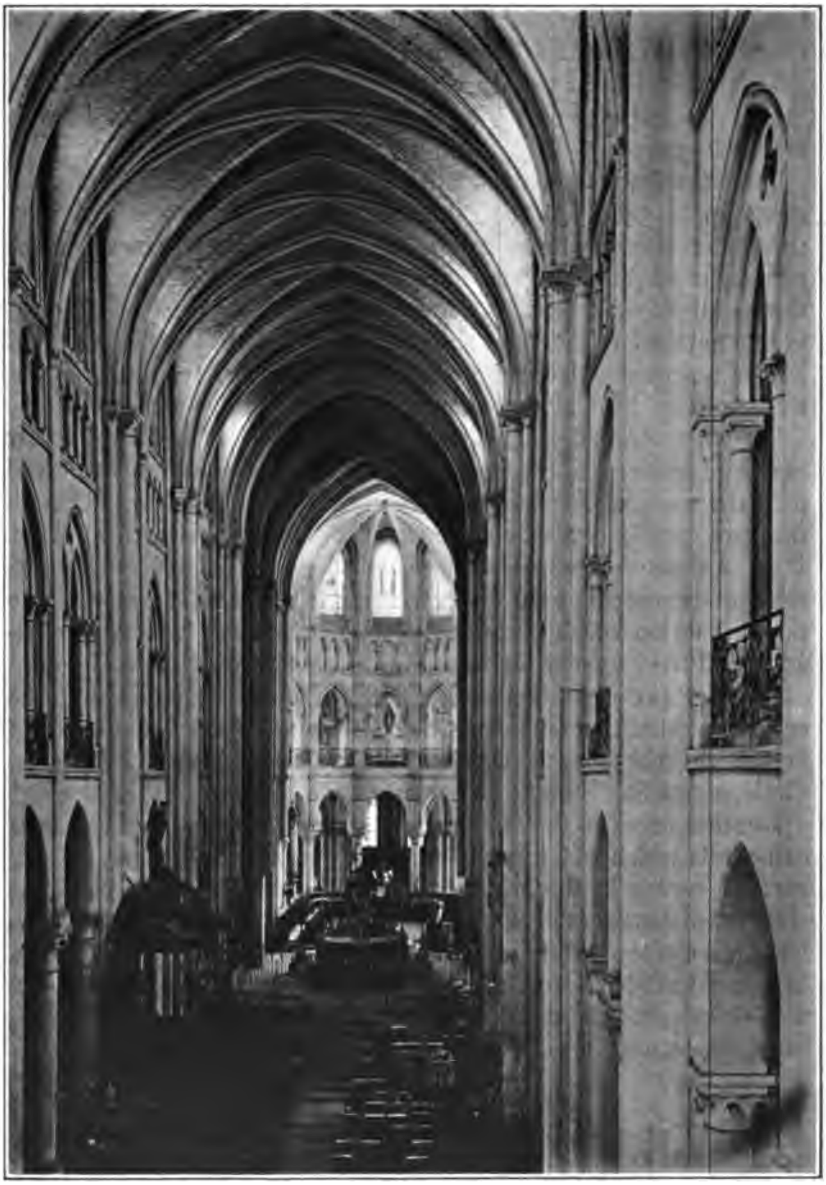
*There are several photographs in the 5 x 7 prints of 1903 for the transepts of Notre Dame, but none of them have been so far enlarged. Only one of them is a wholly reliable survey photograph. It shows well defined vertical curves, but very slight widening; about one foot.



120. CATHEDRAL, NOYON. FROM THE ORGAN GALLERY.

are more distinctly seen in this picture than in the one preceding. In the first and second bays on the right, plumb-lines are suspended from poles which project from the gallery. Of still greater importance are the natural plumb-lines which are supplied by the lamp-chains. These make it possible to study the vertical curves for the entire height of the nave.

121 Left side of the nave from the organ gallery. The lamp-chain beside the first pier on the left affords an excellent opportunity to verify the curve.

122 The nave from the pavement. A plumb-line suspended from the small upper gallery, beside the pier on the left at the transept, shows that there is no widening at this point. On the contrary the pier leans slightly into the nave, two inches with a line of forty-three and one-half feet. All four piers at the transept correspond in this particular feature of showing vertical curves without widening. Photographs from the choir gallery which have not been enlarged, show this feature of the transept piers still more clearly.

The Cathedral of Noyon is the most important building, so far observed in France, for proof that vertical curves were employed for their own sake and without reference to a widening, although they are usually connected with it in the naves of churches. Nos. 119-121 show vertical curves in which the very inconsiderable outward divergence is only of such amount as would correspond to the diminution which is connected with the entasis in a classic column, and the transept piers have no divergence whatever.

Another proof to the same effect, that the widening and the curves are distinct refinements, although usually connected, is found in the churches which widen without curves, like St. Loup at Chalons and St. Thomas at Strassburg.

Another proof to the same effect is found in the general rule that cathedrals which widen considerably in the nave frequently exhibit vertical curves in the transept without widening, as regards the contrast of distances between piers at their bases and capitals. This fact appears, for instance, at Amiens in the exhibited photographs. This fact has also been observed in Rheims cathedral and would be much more prominent if a greater number of transept photographs had been made.

COUTANCES.—CATHEDRAL.

123 Vertical curves of the nave. The perpendicular is not well established in this photograph.

SOISSONS.—CATHEDRAL.

124 The nave. The transept piers appear to widen slightly. Such slight variations would be unworthy of consideration if only one cathedral were in question, but it is evident, as these refinements have

disappeared, that they must have disappeared gradually and by reduction to inconsiderable proportions or by limitation to certain special portions of a church. It is certain that this disappearance began during the Gothic period and before the Renaissance. This is rendered positive by the relatively small number of late Gothic churches which exhibit the vertical curves or widening and by the relatively large number of early Gothic churches which exhibit them. St. Jean and St. Pierre at Caen are the only late Gothic examples, so far observed, of the widening.

It is true that the towns visited in France were those distinguished for early and middle Gothic and that not many late Gothic churches were found in these towns. On the other hand the late Gothic churches of North Italy have been found to be generally lacking in refinements. While more extended observations of late Gothic centres in Northern Europe are to be desired, the general result may be anticipated that they will show the quality and amount of refinements employed in late Gothic to diminish, by contrast with the earlier mediæval periods.

From these considerations the conclusion may be drawn that a careful study and mention should be made of monuments exhibiting traits which are in themselves unimportant or inconsiderable, but which are related to others which are more prominent and more important. The consideration of dates in relation to such observation is very important. It may therefore be noted here that so inconspicuous a case of widening as that at Soissons is a rare thing in 13th century Gothic as so far examined.

Chartres Cathedral may be an instance of the absence of vertical curves in early Gothic.

CATHEDRAL OF CHARTRES.

125 Tentative observations for the existence of vertical curves in this cathedral have been made by Prof. John F. Weir, Director of the Yale School of Fine Arts, and also by the writer, but the only survey photograph so far made of the interior does not appear to support these observations. It is not wise to trust the eye in sighting for vertical curves, when not aided by well-established perpendicular lines. This is especially the case because in all vaulted churches, the vaulting ribs in the distance, which curve away from the lines of the piers nearer to the foreground, tend to produce an optical illusion that the piers curve in the opposite direction, even though they really exhibit straight lines. This is a warning which should be carefully considered by other observers, never to trust the eye when not aided by perpendicular sighting lines. As regards the suspension of perpendicular lines it should be added that suspension of lines from the galleries is insufficient, because the deflection fre-

quently begins at a higher altitude. If, for instance, the inclination of the transept piers of Notre Dame at Paris were to be determined by the plumb-line seen in No. 65, the resulting conclusion would be that the piers are practically perpendicular, which is not the case. The deflection begins higher up. A line from the triforium at Amiens would also be inconclusive for the same reason. Such a line is valuable for establishing a perpendicular which can be carried higher in a photograph, but is useless for observations limited to the given height.

(For this reason no satisfactory account can be given at present of the *Abbaye aux Hommes* or of the *Abbaye aux Dames* at Caen. Curves were apparent to the eye in both these churches, but the suspension of a plumb-line from the gallery failed to verify their existence and the taking of photographs was consequently abandoned. At a later stage of the observations in 1903, it became evident that the negative evidence supplied by plumb-lines suspended from a gallery was inconclusive, but there was not time to return to Caen for more definite observations. The best evidence is that furnished by a photograph which is made by a carefully levelled camera, with an absolutely rectilinear lens.)

The Cathedral of Chartres offers a phenomenal instance of the pavement sloping upward toward the choir. This construction was observed by the surveys of 1895 in more than eighty-five Italian churches (Arch. Rec., Vol. VI., No. 2. "Perspective Illusions in Mediæval Italian Churches").

By careful levelling the pavement of the nave at Chartres was found to slope up from the main door, as far as the choir, three feet seven inches (distance of two hundred and seventy-nine feet). If this slope were continued to the rear of the choir at the same rate it would amount to nearly six feet for the entire length of the church, but the pavement of the choir steps up and has also been relaid.

The slope of the side aisles is uniform and unbroken from the façade to the termination of the choir but is not so pronounced, for the reason that the aisles are raised at the façade above the level of the nave (four steps on the left, combined height 2.98; two steps on the right, combined height .98). At the transepts the less pronounced slope of the aisles, starting from a higher level, and the more pronounced slope of the nave, starting from a lower level, unite in one slope, which is then prolonged in the aisles of the choir, at the original pitch which is found in the aisles of the nave.

The pavement of St. Jean at Chalons (Romanesque) slopes up nine inches in one hundred and fourteen feet.

St. Michel des Vaucelles at Caen (late Gothic) slopes up nine and one-quarter inches in one hundred and ninety-two feet.

The Cathedral of St. Lo slopes up ten inches in two hundred and sixteen feet.

The slope of St. Alpin at Chalons has already been quoted as one foot one inch in sixty-two feet.

St. Godard at Rouen slopes up four inches in eighty feet.

LISIEUX.—CATHEDRAL.

126 View of the nave. Note-book mentions a widening in the choir. Hasty observation.

POITIERS.—CHURCH OF THE MONASTERY OF MONTIERNEUF.

A Benedictine church of the 11th century; damaged by bombardment during the Huguenot wars and subsequently revaulted and shortened.

127 Left aisle. The widening is shown by a plumb-line suspended from the picture beside the fourth pier; surveyor's rod at that point. Lean about 0.74 in about thirty feet.

128 Right Aisle. The widening is shown by three plumb-lines, suspended from the pictures; surveyor's rod at the third pier. Lean about one foot in about thirty feet.

129 Widening of the right side of the nave. A plumb-line is suspended from the crucifix.

VIENNA.—SCHOTTENKIRCHE.

130 The widening of the choir is estimated at one foot with a width at the pavement of about thirty-six feet. A late Renaissance instance of this refinement, dating 1638. The only other Renaissance instance so far observed is S. Giorgio Maggiore at Venice (by Palladio). See Memoir No. 2 for this observation and for considerations regarding the rapid disappearance of architectural refinements after the opening of the Renaissance period.

Itinerary.

The following towns were visited between the dates of July 9th and July 27th, inclusive, in the order named: Mont St. Michel; St. Malo; Dol; Coutances; St. Lo; Bayeux; Caen; Lisieux; Evreux; Chartres; Rouen; Beauvais; Noyon; Laon; Rheims; Chalons; Soissons. One hundred and two glass negatives were made during this time.

The dates of July 28th to Aug. 1st were occupied in preliminary observations in Notre Dame at Paris, in obtaining permits for making photographs in Notre Dame, and in preparations for a visit to Constantinople.

The dates of Aug. 2d to Aug. 28th were taken up by the trip to Constantinople and the return to Paris, including stops at Vienna and Strassburg on the return trip. Thirty-eight negatives were made during this time.

The dates of Aug. 29th to Sept. 12th were devoted to work in Notre Dame. The observations at Amiens were made on the dates of Sept. 14th-19th (fifty-five negatives). Four negatives were also made at Beauvais on the 19th. On Sept. 20th-22d twenty-one negatives were made at St. Quentin.

Work was resumed in Notre Dame on the dates of Sept. 23d-25th.

Between the dates of Sept. 26th and Sept. 29th, visits were made to Periguex, Angoulême, Poitiers, Tours, and Chartres (revisited) and twenty-nine negatives were made.

Work was resumed on Notre Dame between the dates of Sept. 30-Oct. 3d. Eighty-five negatives were made of this cathedral, most of which are available for enlargement.

These views are generally interiors, which required an average exposure of not les than sixty minutes. The average time required for the interior exposures at Amiens was not less than forty-five minutes each. The interior at Chartres was exposed for two hours and a half, and is still under-exposed.

Conclusion.

Although the photographs described in the foregoing list include several cathedrals of the transition period from Romanesque to Gothic (Laon and Noyon especially); and many of the early Gothic time, the only Romanesque churches represented by enlargements are St. Remi at Rheims and two churches at Poitiers. This deficiency for the Romanesque period is made good by earlier observations in Italy (see bibliography). The general deficiency of Romanesque illustrations for France is due to the shortness of the time which could be allotted to the work and the fact that the northern French towns are almost wholly represented by Gothic.

The only towns visited in central or southern France were Periguex, Angoulême, Poitiers and Tours.

The Romanesque Cathedral of Periguex has been wholly rebuilt in the 19th century. It is impossible to say what refinements it may have exhibited. The Cathedral of Angoulême shows widening in the transepts (survey photograph not enlarged). The facts for the nave are doubtful. It appears to have suffered from modern repairs.

At Poitiers the (early Gothic) Cathedral offers a remarkable case of constructive perspective illusion (Fergusson, History of Architecture, Vol. I., p. 489.) but has no widening or vertical curves. St. Radegonde (Romanesque) shows widening in the choir only.

Notre Dame la Grande has no widening or interior vertical curves. For the façade, see No. 112. St. Hilaire has been so rebuilt that no conclusions can be drawn from this church.

The cathedral of Tours has a deflected plan. It has no widening or vertical curves.

The only places visited in 1903, which have not been previously illustrated or mentioned in these pages, outside of the Itinerary, were Mont St. Michel; St. Malo; Dol; St. Lo; Bayeux; and Evreux.

At Mont St. Michel the indications for the vertical curves are unmistakable, but they have been largely obliterated by modern repairs and will probably soon disappear altogether, in consequence of the restorations now going on.

The unimportant cathedral of St. Malo has a Renaissance constructive leaning façade, leaning about five inches in about fifty feet. I was advised of this by a friend, Retired Commander Rooper of the British Navy, and went to St. Malo to verify the observation. Note-book mentions widening in the choir.

Observations at Dol, as recorded in note-book, mention vertical curves in the cathedral nave. No photographs were taken.

No refinements were observed at Bayeux or at Evreux or in St. Stephens at Vienna.

From the accounts given in this Memoir it will appear that twenty-seven towns were visited between the dates of July 9th and Oct. 3d, inclusive, in 1903. In these twenty-seven towns, twenty-nine churches and cathedrals were found to exhibit the vertical curves or the widening refinement, with or without vertical bends. Chartres, Lisieux and Soissons are considered as doubtful cases and are not included in this count.

It may therefore be confidently concluded that a very large proportion of the mediæval cathedrals and churches in northern Europe will be found to exhibit similar refinements.

The expenses of the investigation described were supported by generous contributions from Mr. and Mrs. August Lewis of New York and from the Trustees of the Brooklyn Museum.

Museum of the Brooklyn Institute of Arts and Sciences.
April, 1904.

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